Non-Invasive Ventilation and High Flow Oxygen Therapy in COPD

정치량

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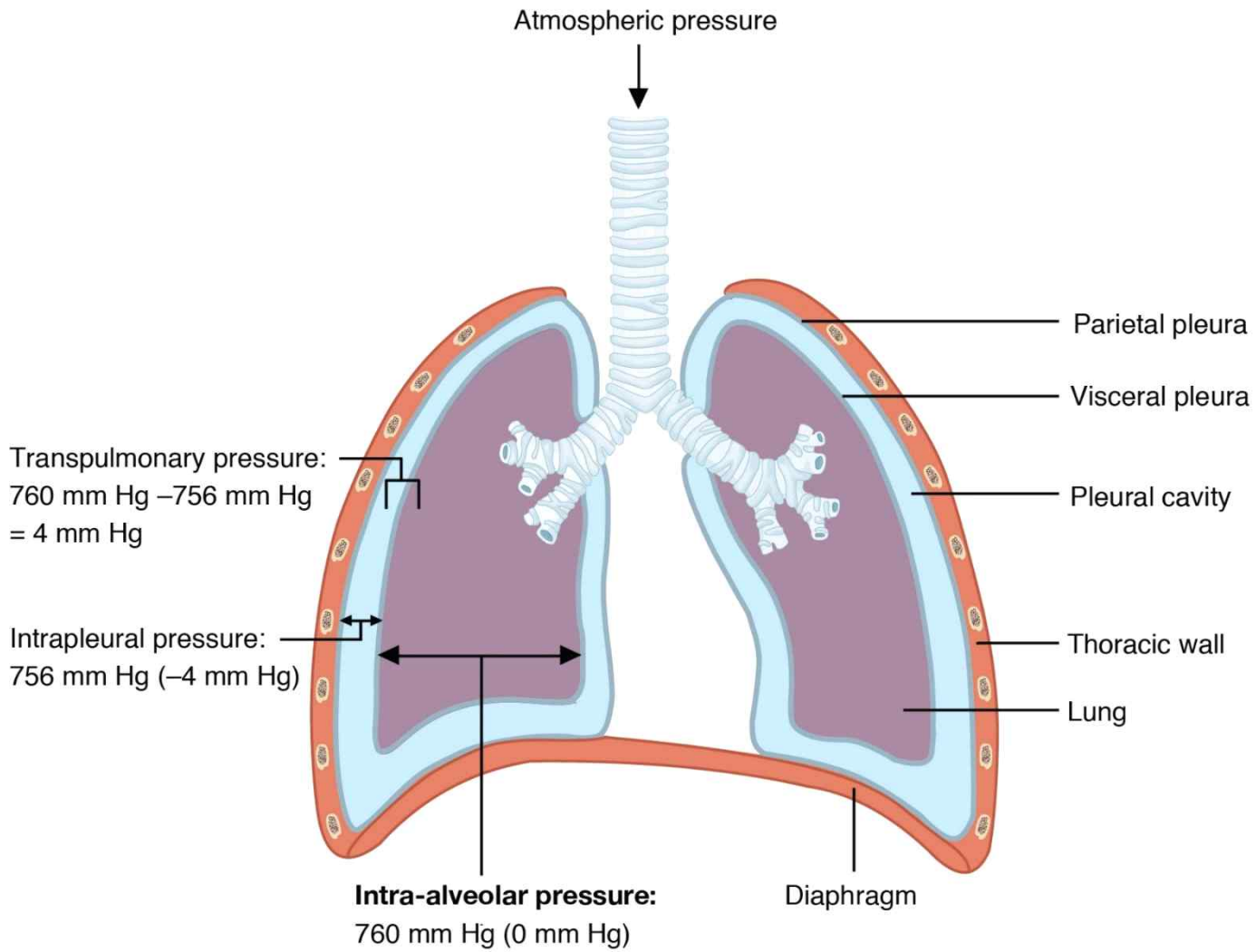
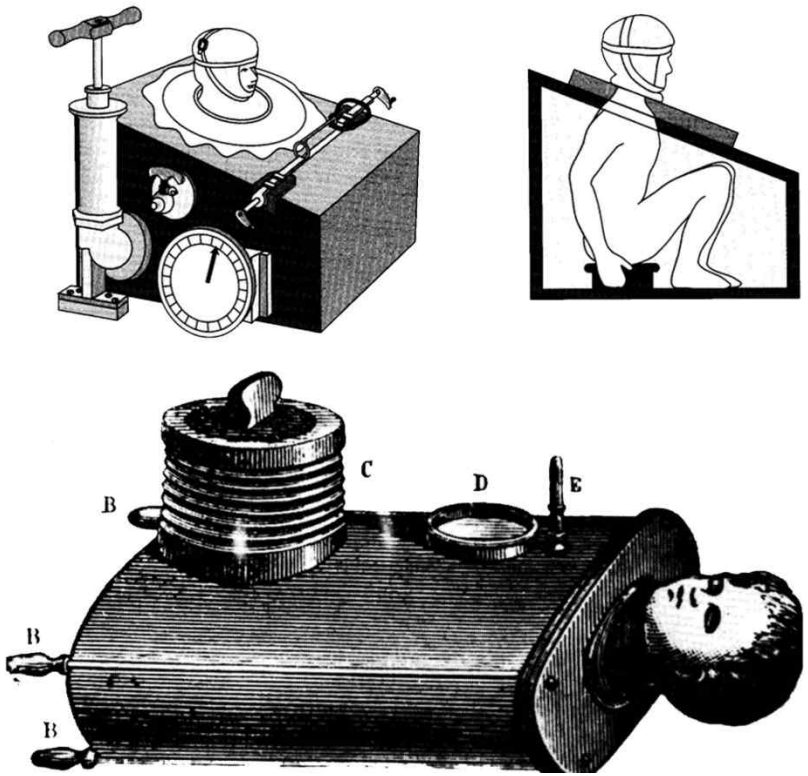
성균관대학교 의과대학 내과학교실

Physiology, Intrapulmonary pressure

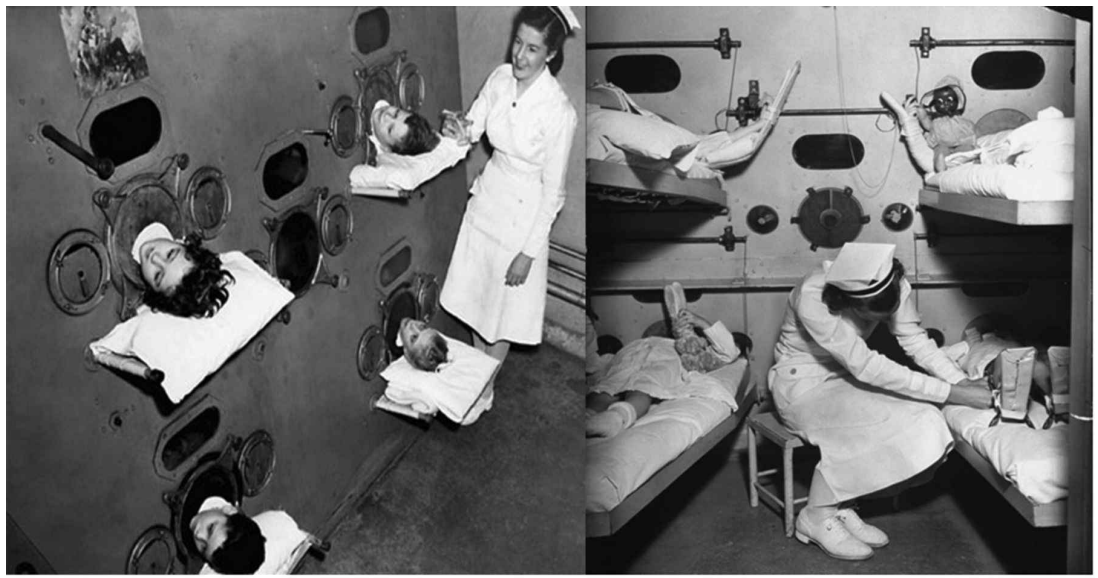


Negative Pressure

19th-century negative-pressure ventilators.



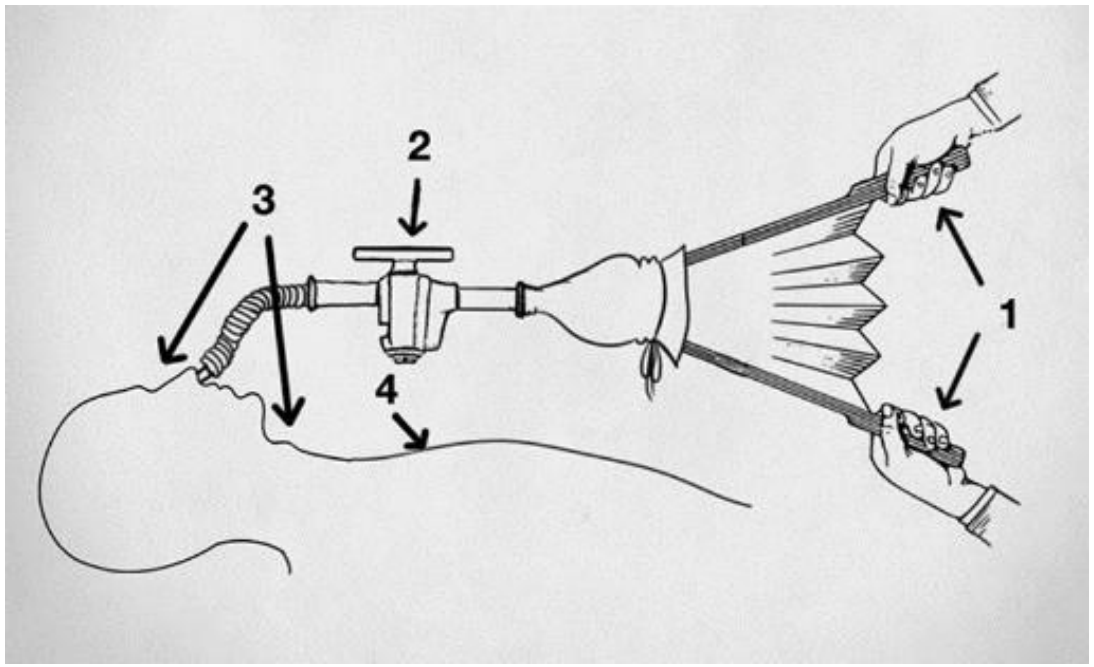
Multi-person negative-pressure ventilator at Boston Children's Hospital, 1950s



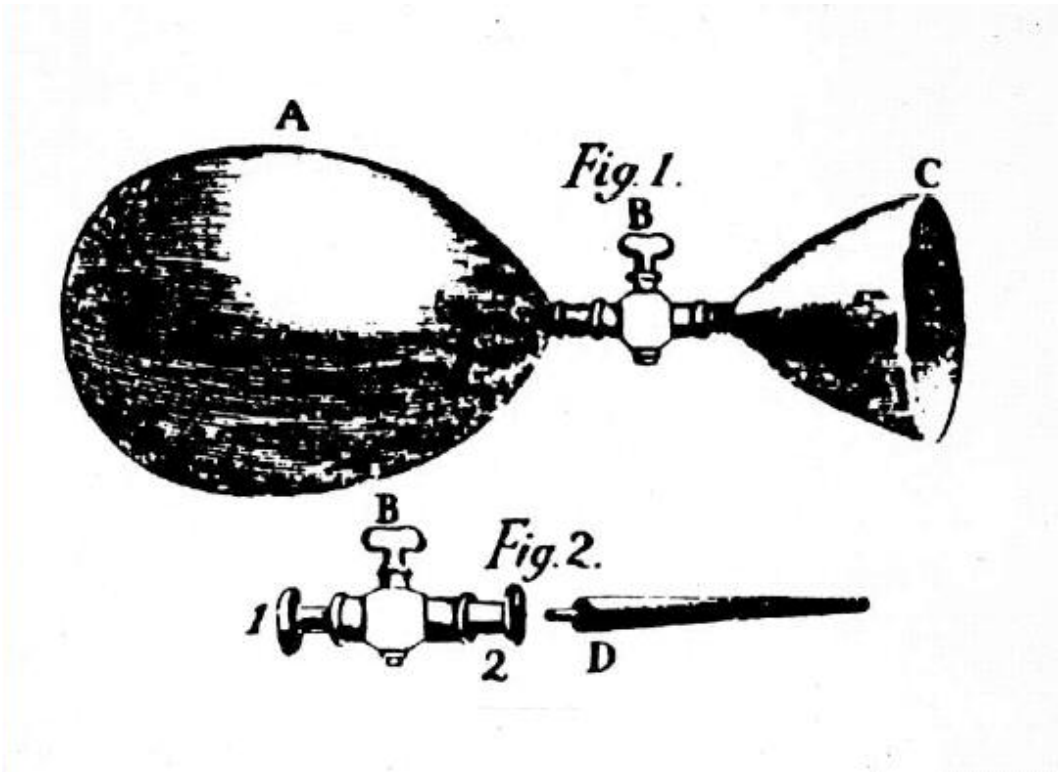
Respiratory Care August 2011, 56 (8) 1170-1180

History of Positive pressure ventilation

1756’ Coleman’s “bellows-to-nose” London



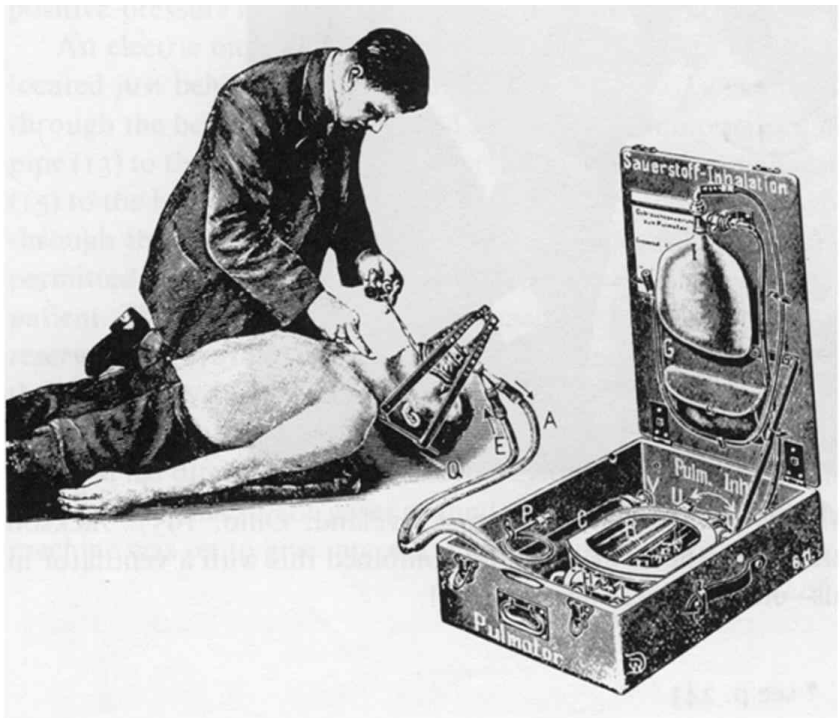
1780’ Chaussier’s bag and mask France



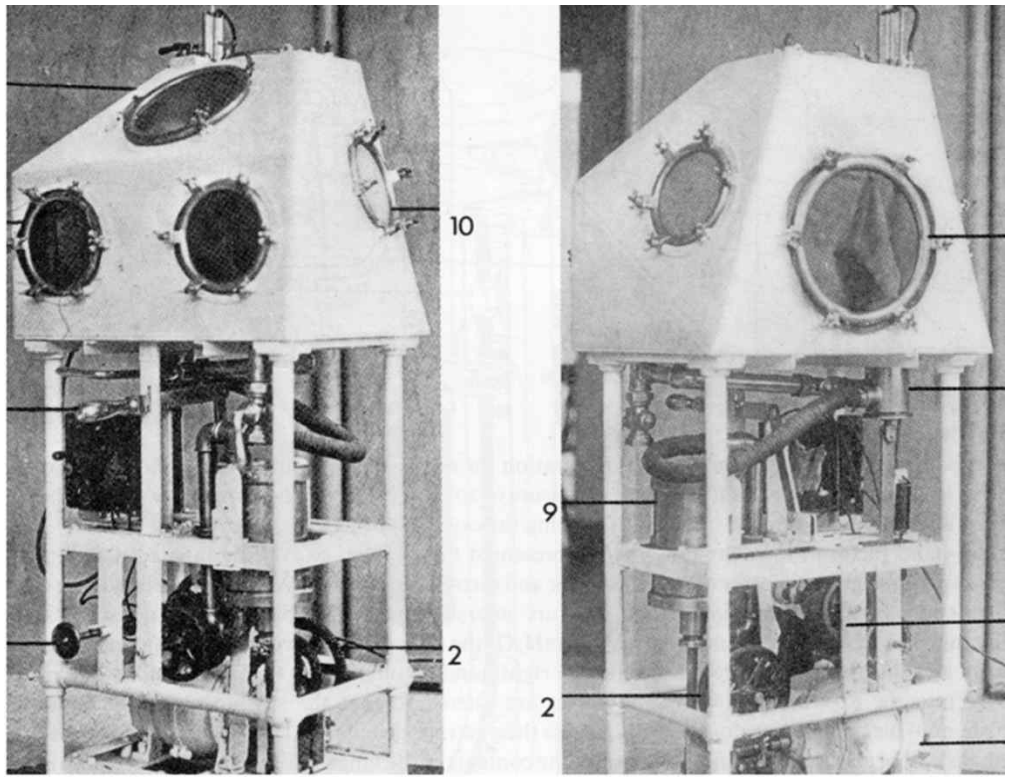
Anesthesiology 2016, Vol.124, 301-311

History of Positive pressure ventilation

1910’ Dragger Pulmomotor Germany



1910’ Green and Janeway rhythmic inflation apparatus



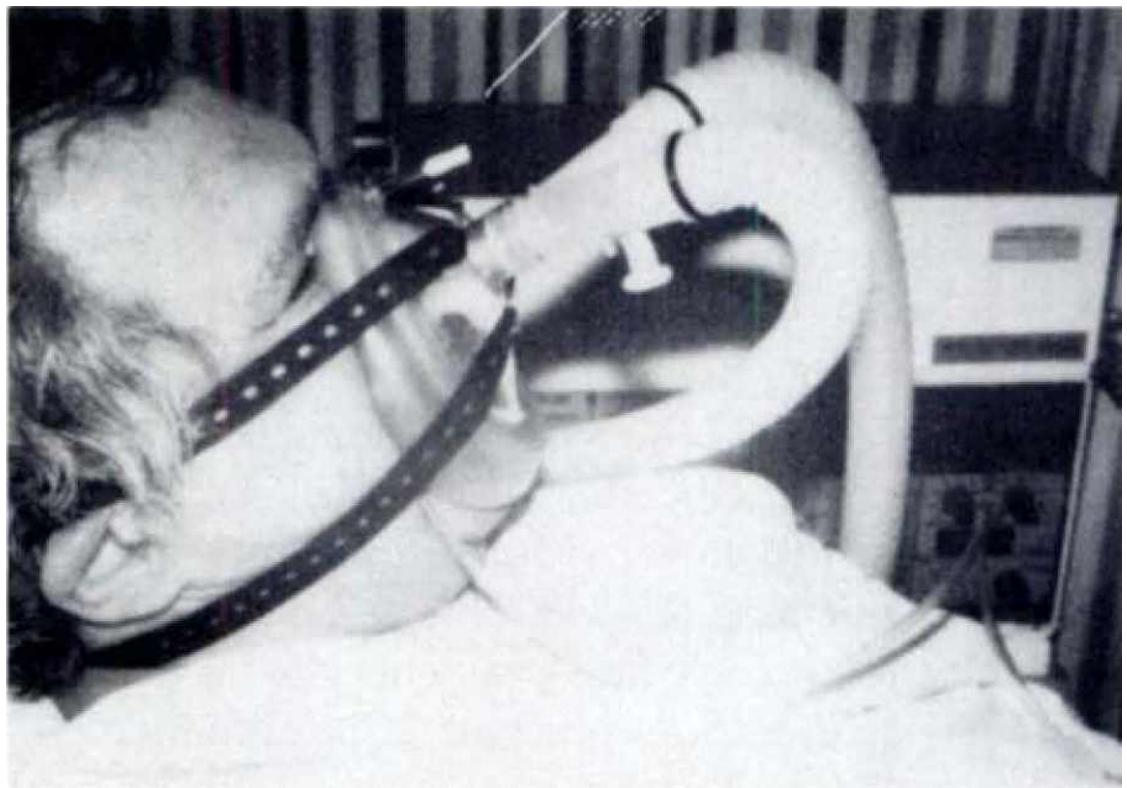
Respiratory Care August 2011, 56 (8) 1170-1180

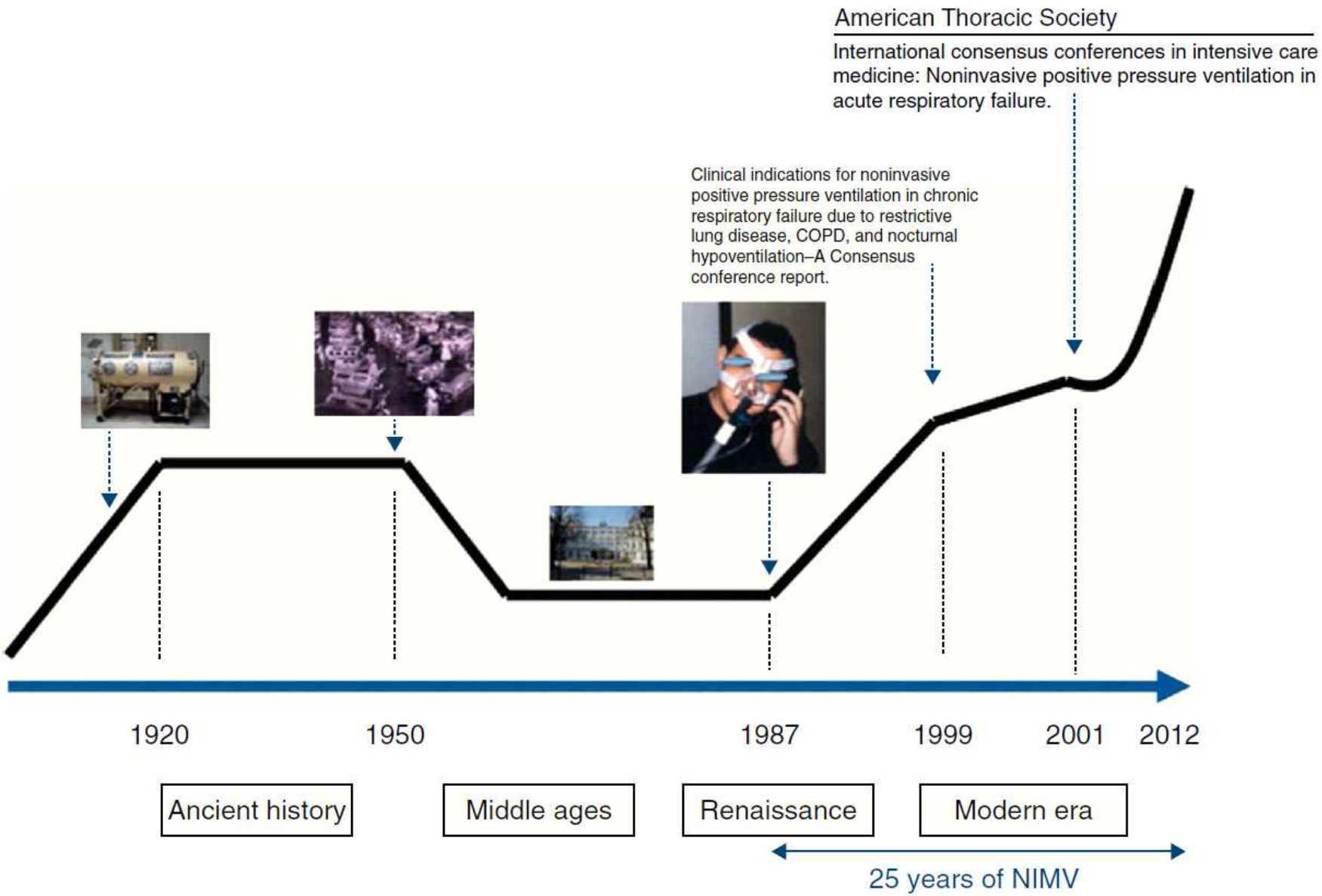
clinical investigations in critical care

Noninvasive Face Mask Ventilation in Patients with Acute Respiratory Failure*

Gianfranco Umberto Meduri, M.D., F.C.C.P.;†
Craig C. Conoscenti, M.D.; ‡Phillip Menashe, M.D.;§
and Sreedhar Nair, M.D., F.C.C.P.||

(Chest 1989; 95:865-70)





*S. Díaz Lobato, S. Mayoralas Alises / Arch Bronconeumol. 2013;**49(11)**:475–479*

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11

Leak Port Circuit vs Active Exhalation Valve

Single limb with leak port (or vented circuit)

CO_2 re-breathing (+)
Intentional leak (+)

vs.

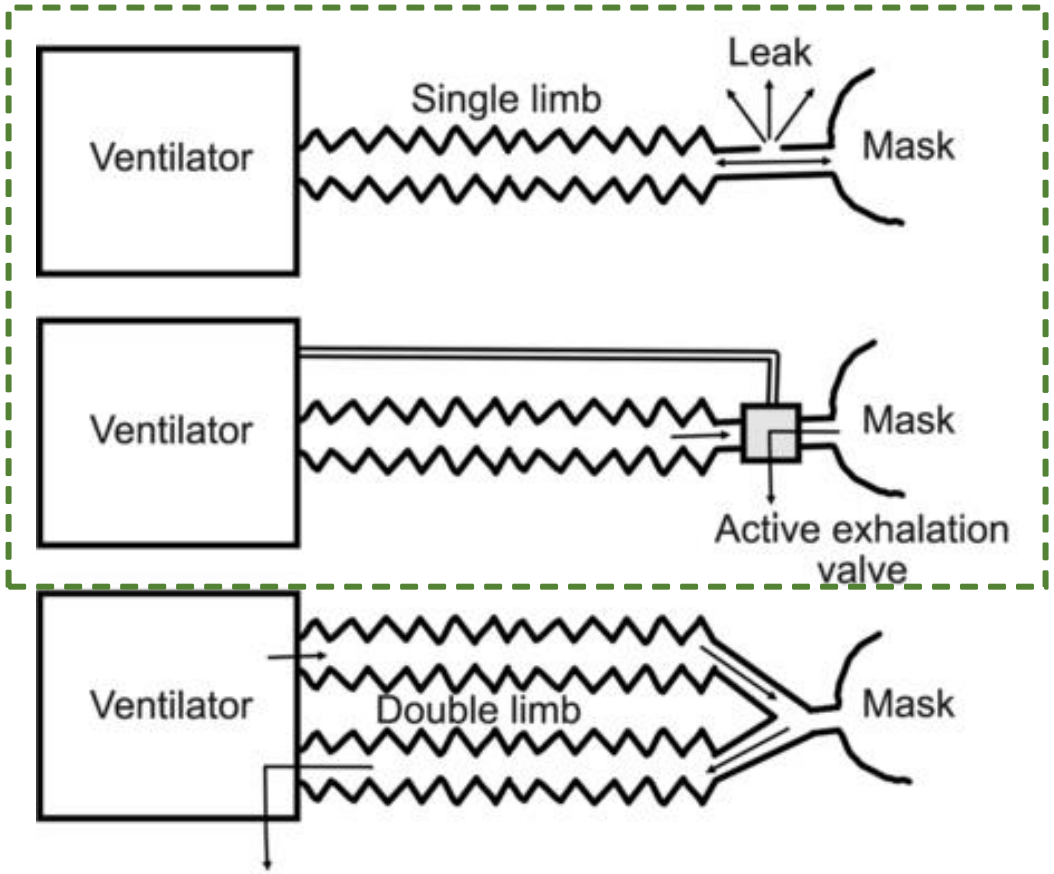
Single limb with active exhalation valve (non-vented circuit)

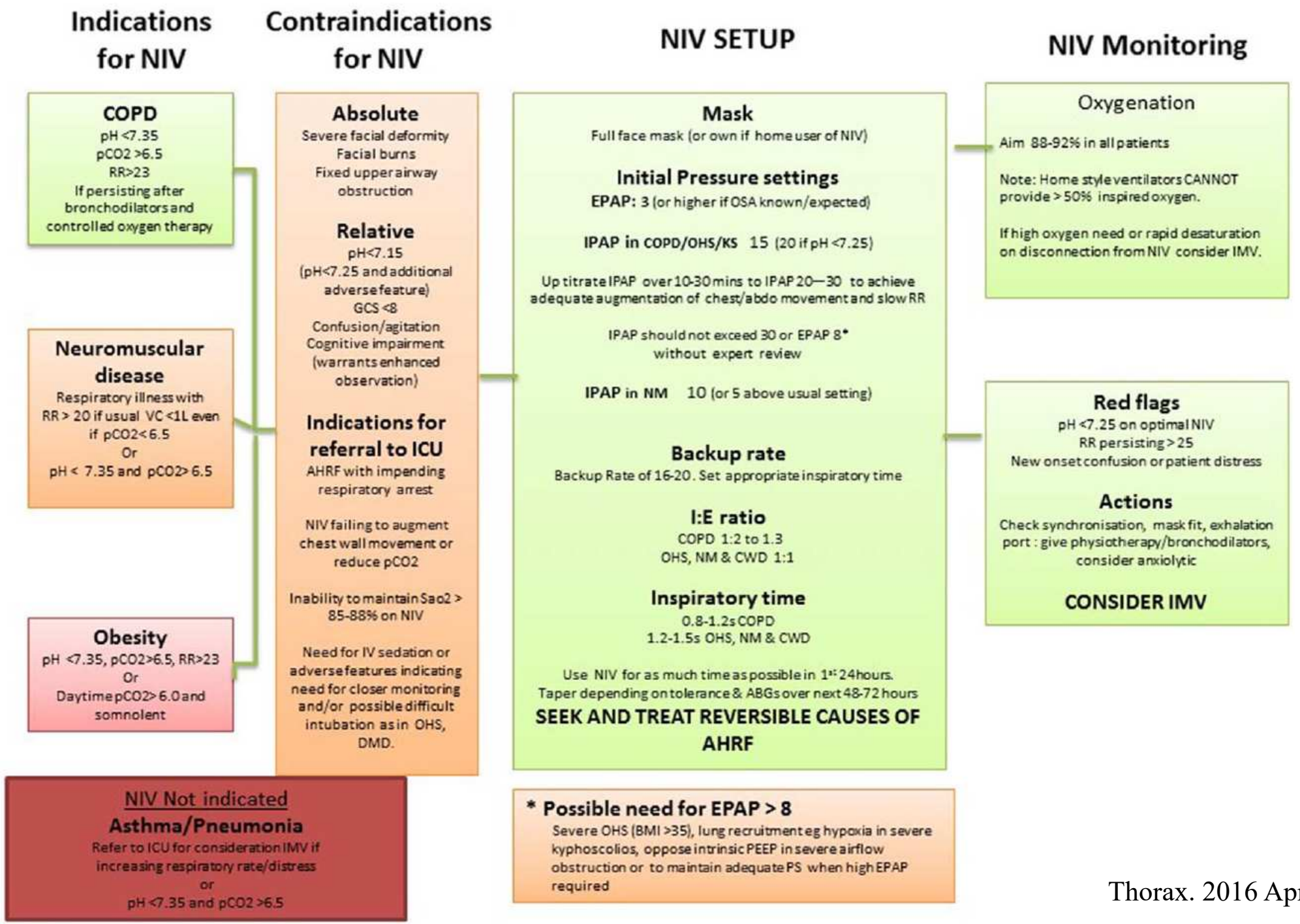
Double limb as in ICU vent

CO_2 re-breathing (-)
Intentional leak (-)

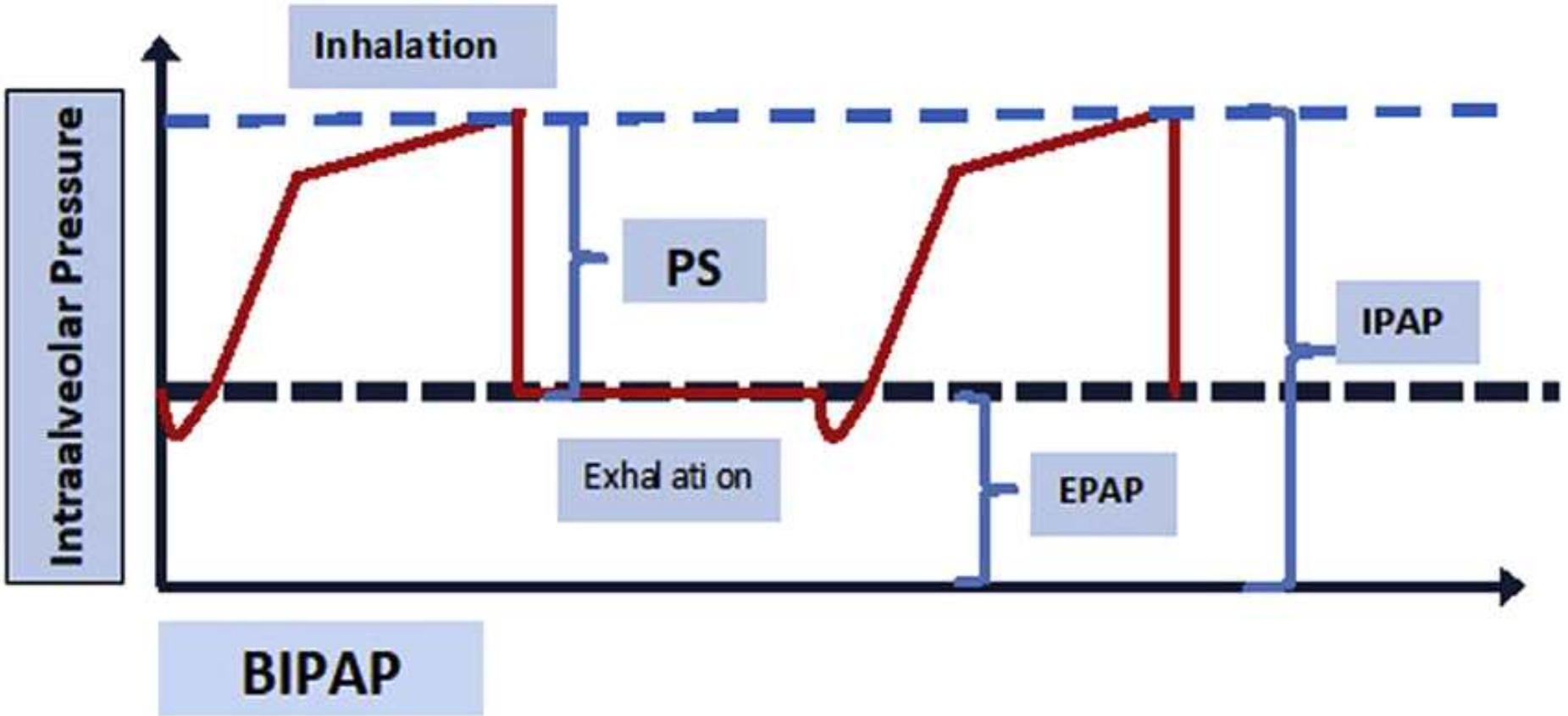
Circuit configurations for noninvasive ventilation

- **Intentional leaks**
  - Exhalation valves (hole) in distal tubes or masks
  - Different by masks and pressures applied
  - Important for CO_2 washout
- **Unintentional leaks**
  - Around masks
  - Always occurs





Thorax. 2016 Apr;71 :ii1-35.


Inhalation
Intraalveolar Pressure
PS
IPAP
Exhal ati on
EPAP
BIPAP

Monitoring NIV

- Initial period may be '**labor intensive**'
- Facilities to intubate always available
- Consider intubation if:
  - No improvement in 1st hour
  - Deterioration in level of consciousness
  - NIV poorly tolerated
  - Inadequate secretion clearance

Risk Factors for NIV Failure (5-60%)

Acute hypercapnic respiratory failure
Poor neurologic score: Glasgow Coma Score < 11
Tachypnea: > 35 breaths/min
pH < 7.25
Acute Physiology and Chronic Health Evaluation score > 29
Asynchronous breathing
Edentulous
Excessive air leak
Agitation
Excessive secretions
Poor tolerance
Poor adherence to therapy
No initial improvement within first 2 h of noninvasive ventilation
No improvement in pH
Persistent tachypnea
Persistent hypercapnia
Acute hypoxemic respiratory failure
Diagnosis of ARDS or pneumonia
Age > 40 y
Hypotension: systolic blood pressure < 90 mm Hg
Metabolic acidosis: pH < 7.25
Low P_{aO_2}/F_{IO_2}
Simplified Acute Physiology Score II > 34
Failure to improve oxygenation within first hour of noninvasive ventilation: P_{aO_2}/F_{IO_2} > 175 mm Hg

(Data from reference 99.)

- Selection of inappropriate ventilator settings
- Assess clinical trajectory after 1–2 h of initiation of NIV
- rapid shallow breathing index (RSBI)

Respir Care 2009;**54**(1):62-70.

Prognostic factors associated with NIV failure

Patient factors
Radiological consolidation
High secretion load
Poor nutritional status
Intervention factors
Patient ventilator asynchrony
High leak levels
Outcome factors
Failure to have physiological improvement in gas exchange in 1st hour of therapy

J Thorac Dis. 2018 Jan; 10(Suppl 1): S71–S79.

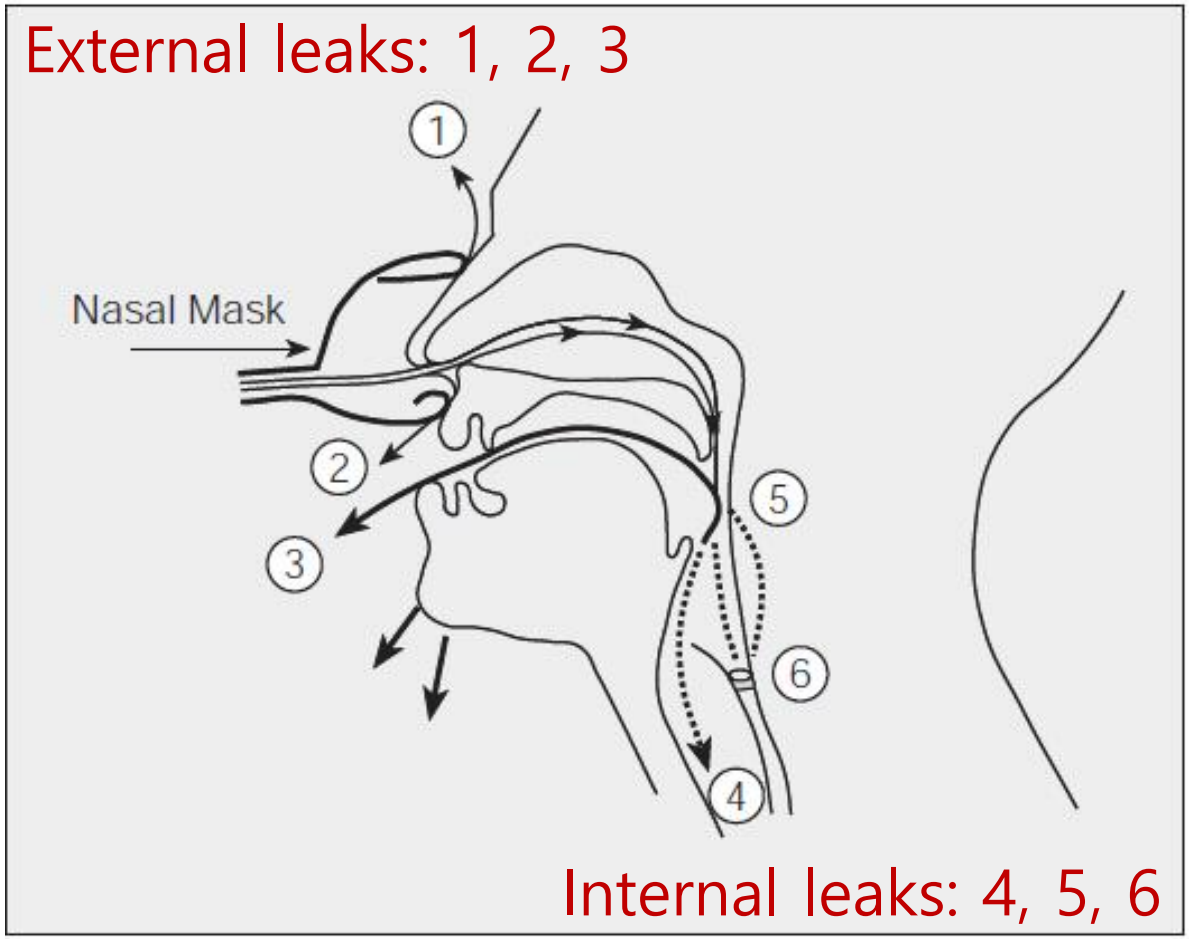
Technical issues: NIV is failing

Table 3 Technical issues: a guide for when NIV is failing

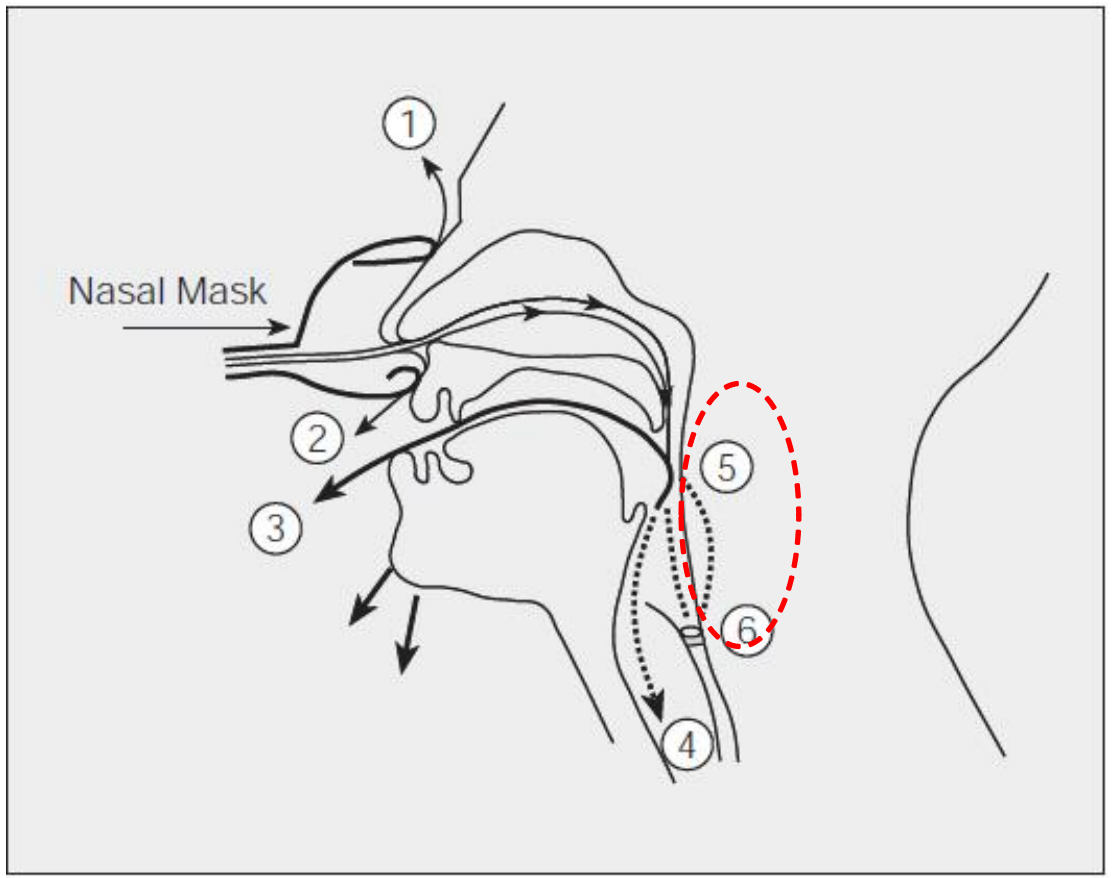
Problem	Cause(s)	Solution (s)
Ventilator cycling independently of patient effort	Inspiratory trigger sensitivity is too high Excessive mask leak	Adjust trigger Reduce mask leak
Ventilator not triggering despite visible patient effort	Excessive mask leak Inspiratory trigger sensitivity too low	Reduce mask leak Adjust trigger For NM patients consider switch to PCV
Inadequate chest expansion despite apparent triggering	Inadequate Tidal volume	Increase IPAP. In NM or chest wall disease consider longer Ti
Chest/abdominal paradox	Upper airway obstruction	Avoid neck flexion Increase EPAP
Premature expiratory effort by patient	Excessive Ti or IPAP	Adjust as necessary

BTS/ICS guideline Thorax. 2016 Apr;71 :ii1-35.

Definitions for Air Leaks



Aerophagia



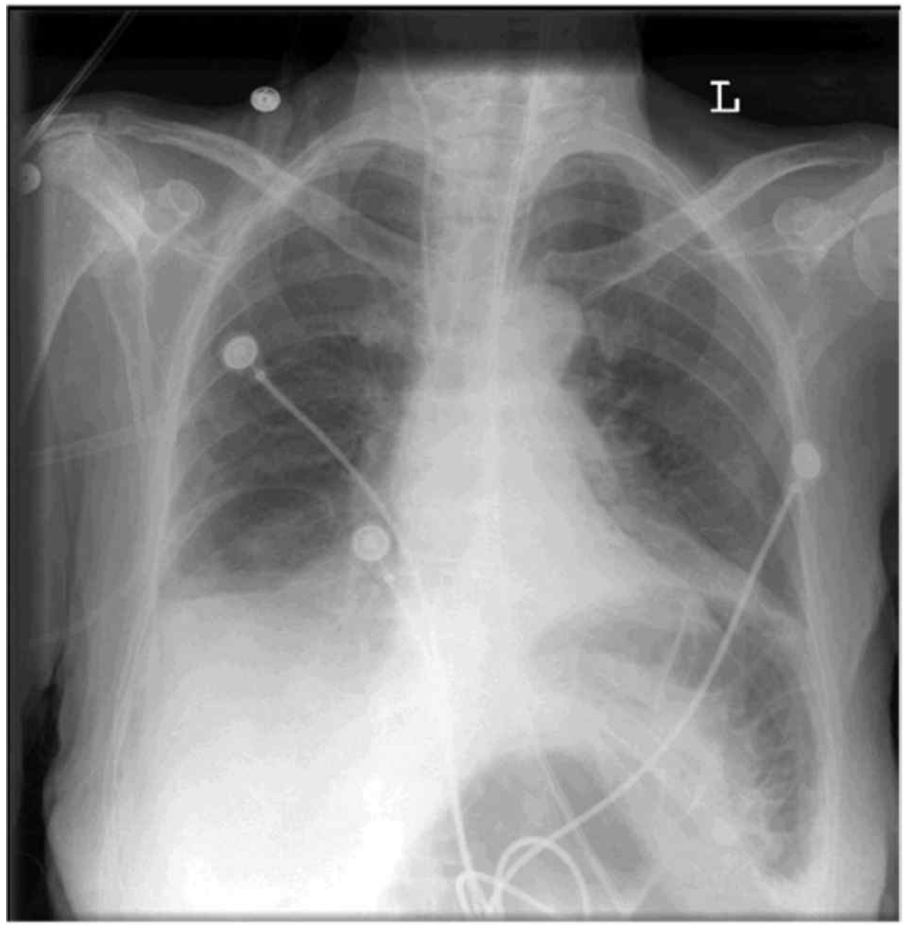
Esophageal sphincter can resist pressure of 15 – 20 cmH_2O.

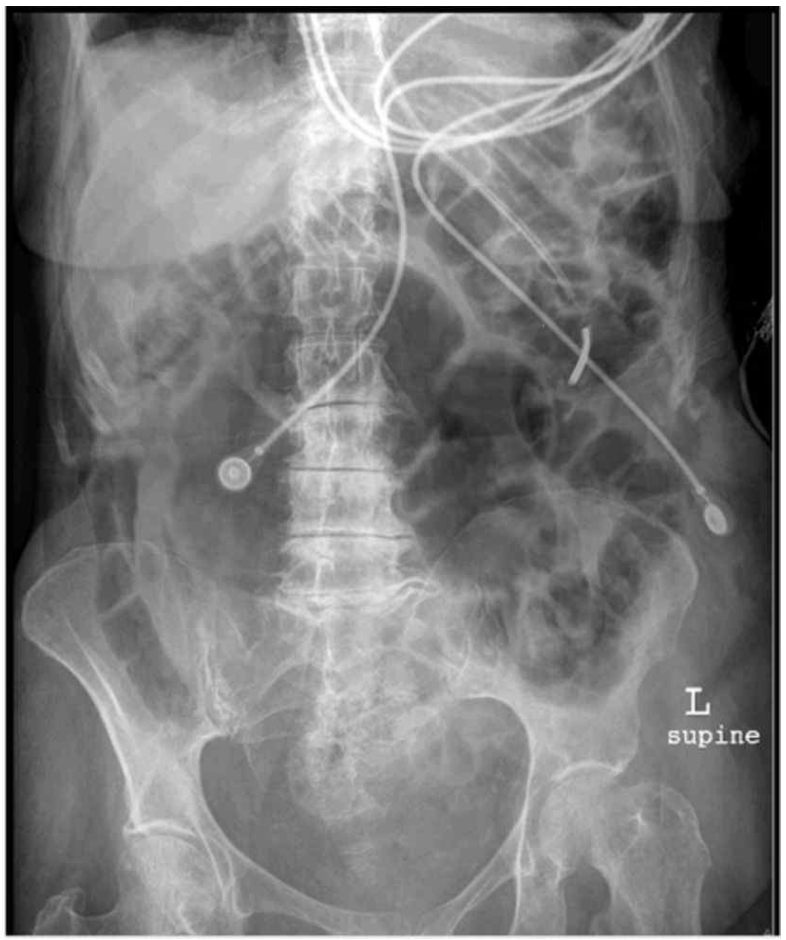
<u>So, at higher pressures, some of air can go to the GI tract</u>

➔ ↓ TV, ↑ Elastic work

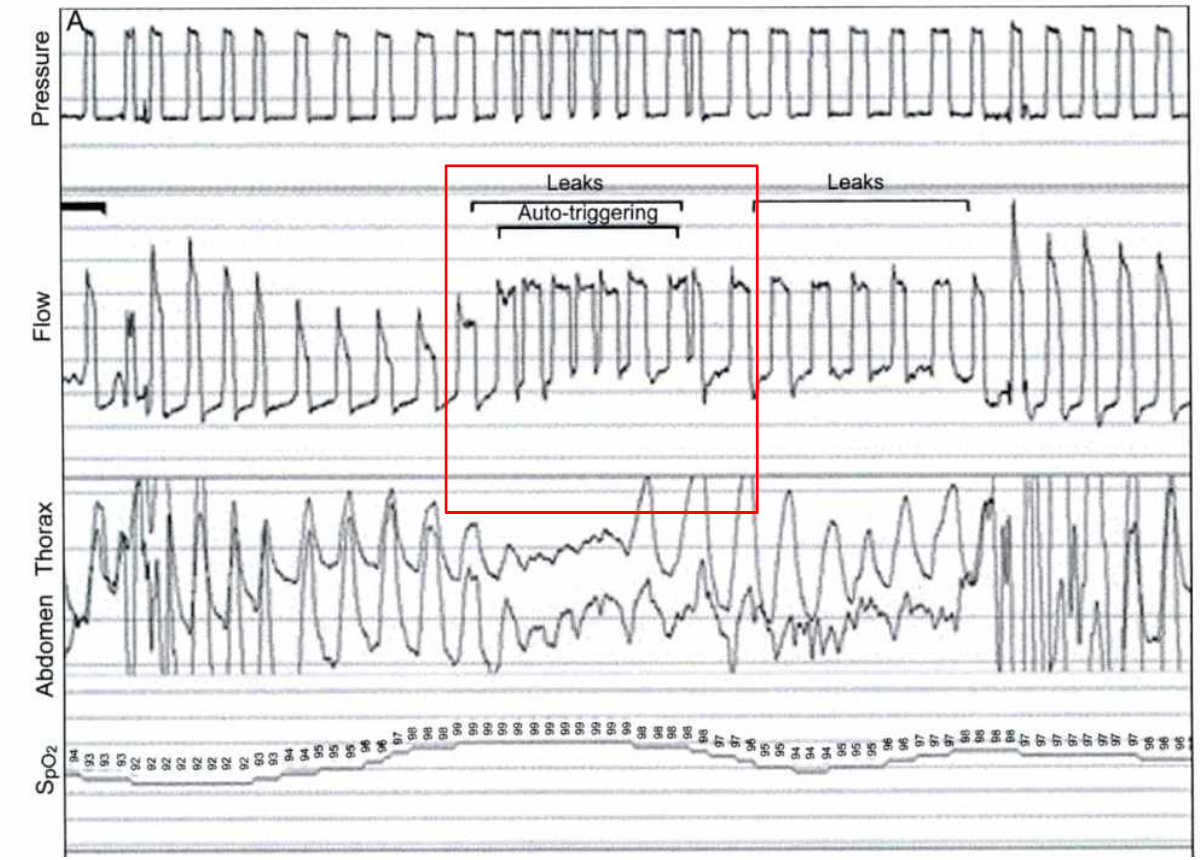
Rabec et al. Arch Bronconeumol 2004;40:508-517

Severe gastric insufflation while receiving NIV.

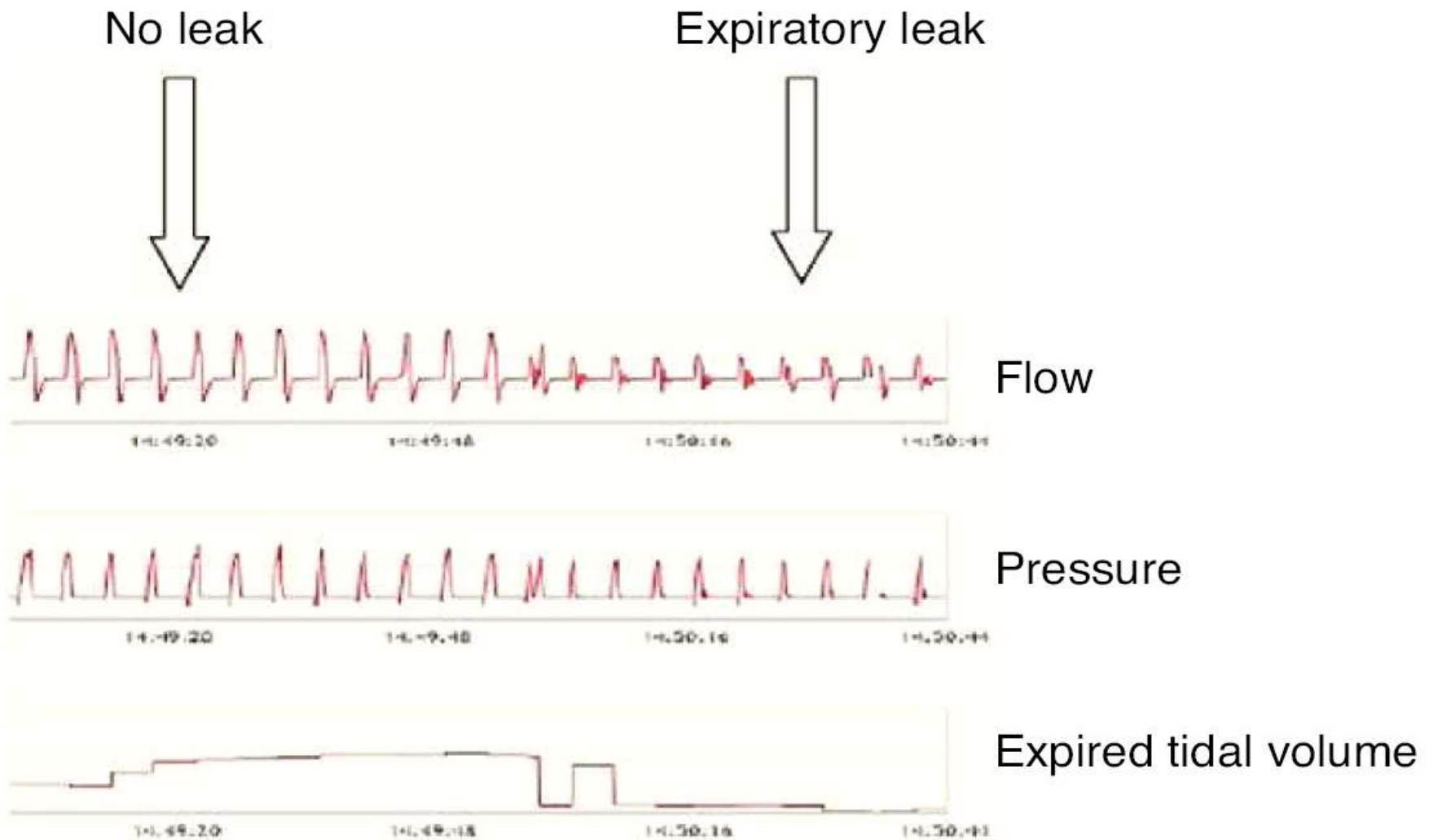




Auto-Trigger



Vrijsen et al. Respir Care 2015;60:1337-1362



Arch Bronconeumol. 2012;48(5):170–178

“Two fingers” and skin protection

Helmet mask for compliance

http://jamanetwork.com/learning/video-player/13008411

Interfaces for noninvasive ventilation.

Top (left to right): nasal mask, nasal pillows, oronasal mask, hybrid mask.

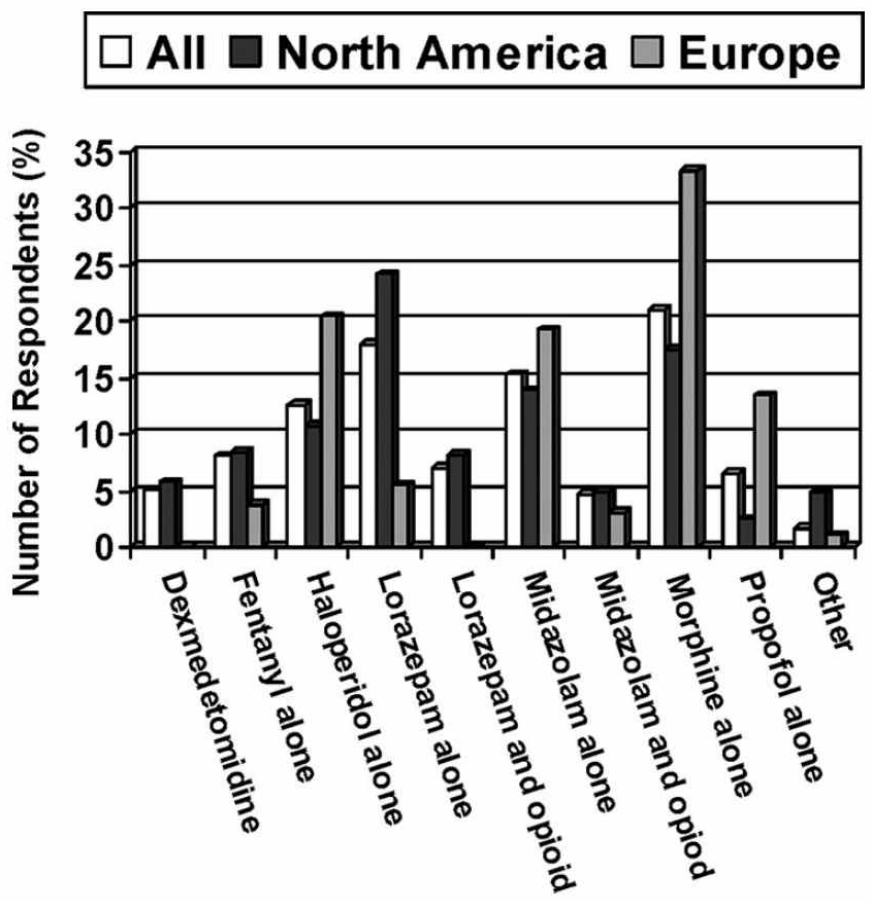
Bottom (left to right): oral mask, total face mask, helmet

http://ersbuyersguide.org/

Respir Care 2009;**54**(1):71-84.

When to sedate,

- 85%, Sedation / 94%, Anagesia and / 72%, hand restraints,
- Benzodiazepine alone (33%), Opioid alone (29%)
- Remifentanil-based sedation
- Dexmedetomidine had favorable outcome



Crit Care Med 2007;**35**(10):2298-2302.

When to intubate,

- To Assess clinical trajectory after 1–2 h of initiation of NIV
  - pH < 7.25
  - RSBI >105
  - lower level of consciousness
  - more hypoxemic
  - No Sx improvement
    - RR

Nocturnal Nasal Intermittent Positive Pressure Ventilation with Bi-level Positive Airway Pressure (BiPAP) in Respiratory Failure*

Richard E. Waldhorn, M.D., F.C.C.P.†

The purpose of this study was to assess the efficacy of bi-level positive airway pressure (BiPAP) ventilation through a nasal mask in the treatment of eight patients with hypoventilatory respiratory failure and nocturnal CO_2 retention. Nocturnal CO_2 retention was significantly reduced in all patients with the application of BiPAP during sleep ($p<0.01$). Daytime somnolence was relieved and dyspnea improved after three months of home BiPAP therapy. All patients tolerated home BiPAP therapy, and two patients who had previously been treated with volume ventilation via nasal mask found BiPAP more comfortable. There were no changes in FEV_1 or FVC after three months of BiPAP. Daytime $PaCO_2$ improved slightly or remained stable in all patients after three months of home BiPAP. BiPAP nasal ventilation is effective in reducing nocturnal CO_2 retention short term in hypoventilatory respiratory failure due to obesity hypoventilation syndrome, chest wall restriction, or neuromuscular disease. Further studies in patients with COPD may be warranted. ***(Chest 1992; 101:516-21)***

BiPAP = bi-level positive airway pressure; EPAP = expiratory positive airway pressure; IPAP = inspiratory positive airway pressure; IPPV = intermittent positive pressure ventilation; REM = rapid eye movement; SIMV = synchronized intermittent mandatory ventilation

Bilevel pressure ventilation, all parameters in volumetric ventilators

RCT - COPD

The New England
Journal of Medicine

Volume 333 SEPTEMBER 28, 1995 Number 13

NONINVASIVE VENTILATION FOR ACUTE EXACERBATIONS OF CHRONIC OBSTRUCTIVE PULMONARY DISEASE

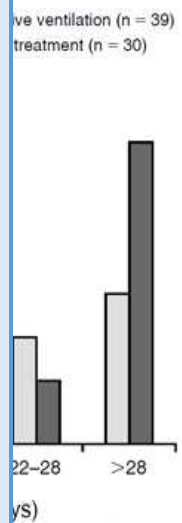
LAURENT BROCHARD, M.D., JORDI MANCEBO, M.D., MARC WYSOCKI, M.D., FRÉDÉRIC LOFASO, M.D., GIORGIO CONTI, M.D., ALAIN RAUSS, M.D., GÉRALD SIMONNEAU, M.D., SALVADOR BENITO, M.D., ALESSANDRO GASPARETTO, M.D., FRANÇOIS LEMAIRE, M.D., DANIEL ISABEY, PH.D., AND ALAIN HARF, M.D.

Noninvasive ventilation

- Standard Treatment
- Non-invasive pressure support ventilation
- 6≥hours /day and depending on the clinical tolerance of the patients
- Spontaneous breathing for 2 hours

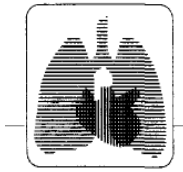
COPD and NIV (85 COPD patients)

- Reduces mortality 74% vs 26%
- Reduces intubation rate 29% vs 9%
- Reduces hospital length of stay 35 vs 23 days



Early stages of modern NIV

Restrictive respiratory failure
Volumetric ventilators
Nasal mask
Adaptation of patients in hospital
Use of nocturnal pulse oximetry



consensus conference

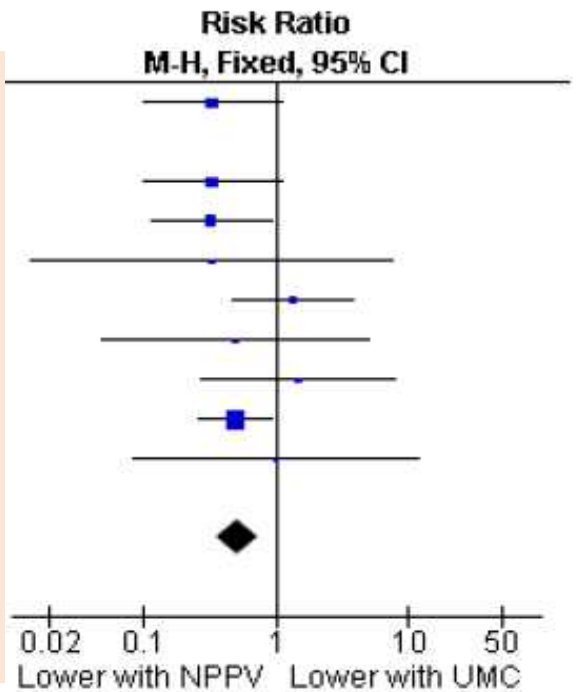
Clinical Indications for Noninvasive Positive Pressure Ventilation in Chronic Respiratory Failure Due to Restrictive Lung Disease, COPD, and Nocturnal Hypoventilation—A Consensus Conference Report*

Underlying Disease	Type 2 Support	Level of Evidence
Adult		
COPD	May be effective	I (discordant RCTs results)
Parenchymal lung disease	May be effective	V
Neuromuscular and chest wall	Effective	III
Sleep-disordered breathing	CPAP effective, NPPV may be effective if CPAP fails	II
Pediatric		
Parenchymal lung disease	May be effective	V
Neuromuscular and chest wall	May be effective	V
Cystic fibrosis	May be effective	V

CHEST / 116 / 2 / AUGUST, 1999

NIV for Acute Hypercapnic RF d/t COPD AE

Figure 3. Forest plot of comparison: 1 NPPV +Usual Medical Care vs Usual Medical Care - Overall, outcome: 1.2 Mortality.

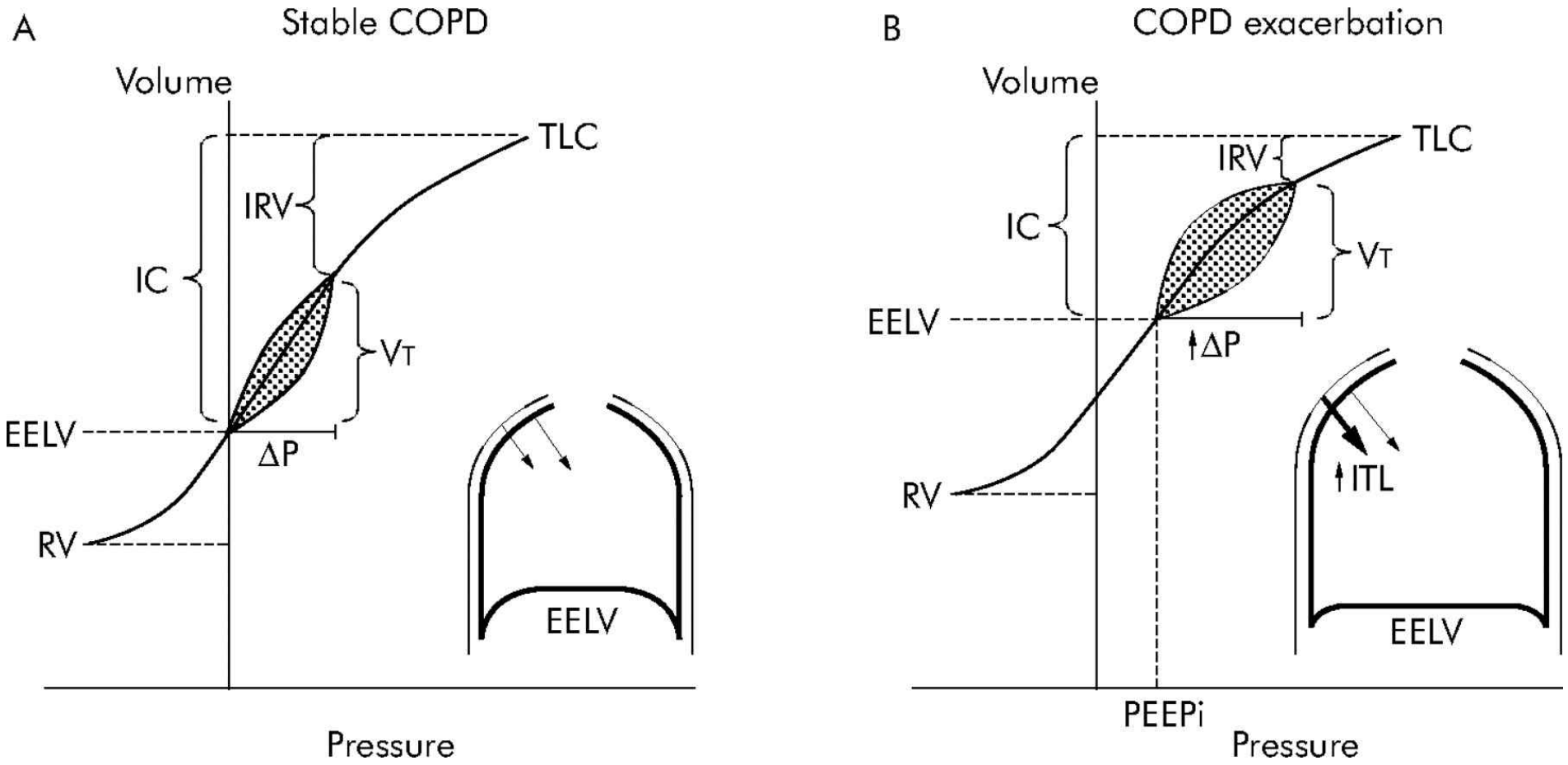


NIV decreased the need for intubation, relative risk (RR) of 0.41 (95% CI 0.33–0.53); (NNT) of 4 (95% CI 4–5).

NIV decreased mortality,
RR of 0.52 (95% CI 0.35–0.76) NNT of 10 (95% CI 7–20).

Cochrane Database Syst Rev. 2017

Negative mechanical effects of dynamic hyperinflation



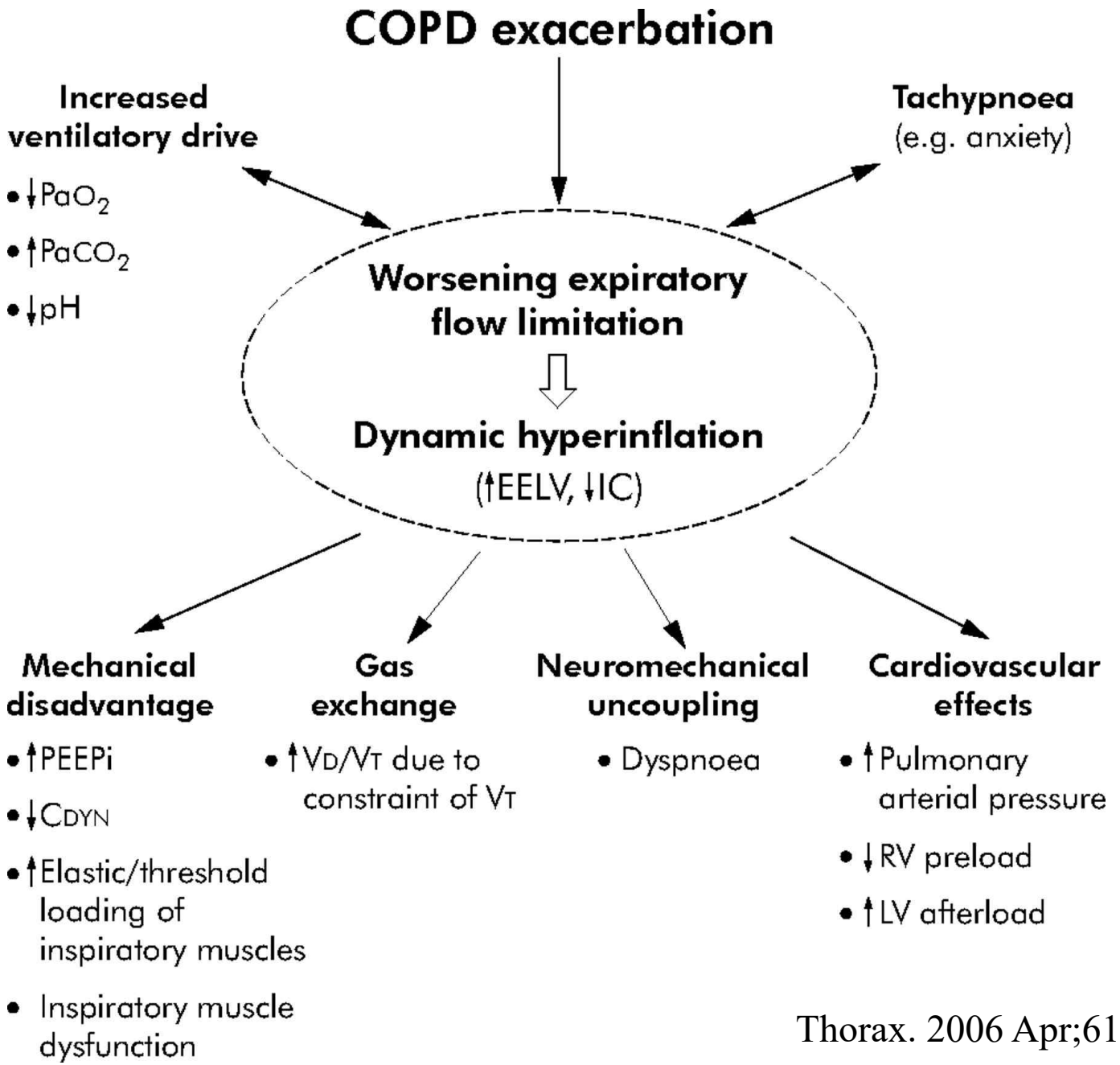
Thorax. 2006 Apr;61(4):354-61.

Cardiac dysfunction during severe COPD exacerbations

- Acute development of DH (and PEEPi) may reduce RV preload as a result of impaired venous return

- Pulmonary artery pressures are generally higher at any cardiac output
  - increased right ventricular afterload

- RVEDP↑ → impair LV filling



Thorax. 2006 Apr;61(4):354-61.

NIV improves gas exchange during COPD exacerbations

- Increases in alveolar ventilation(V_T)
  - increase in PaO_2, a decrease in $PA–aO_2$, and a reduction in $PaCO_2$
- Offloads the inspiratory muscles
  - significant reductions in work of breathing
  - extrinsic PEEP which counterbalances the effects of PEEPi,

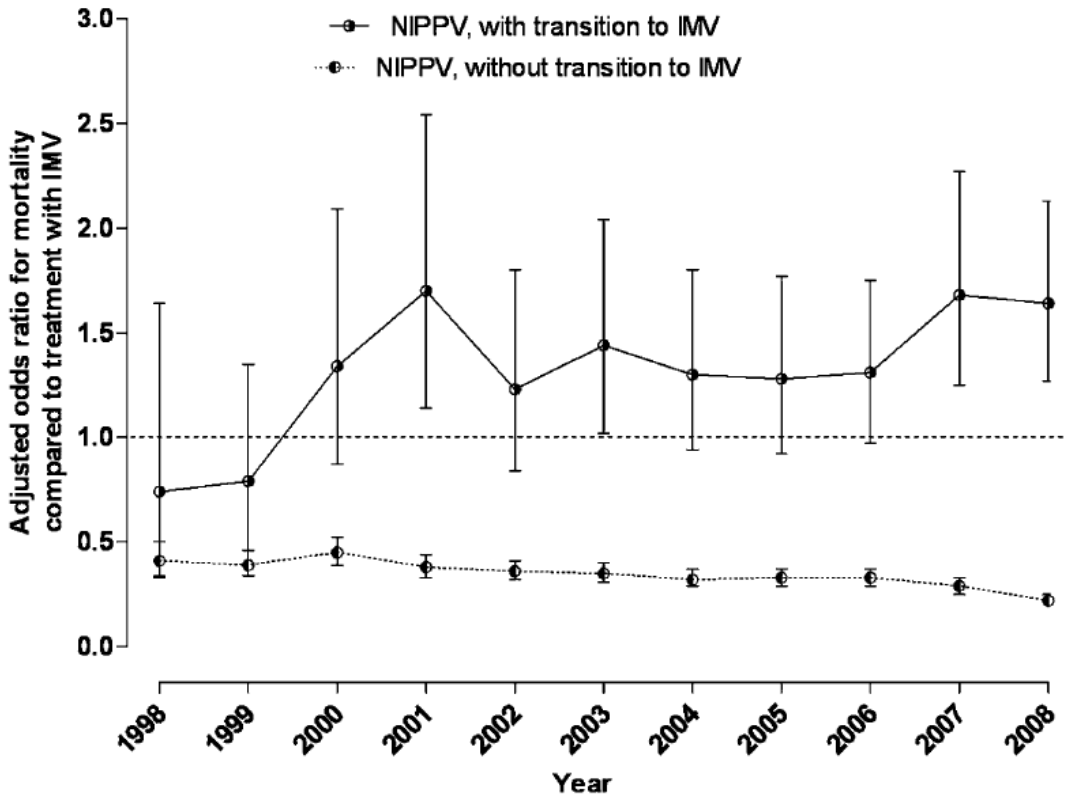
Official ERS/ATS clinical practice guidelines: NIV for acute RF

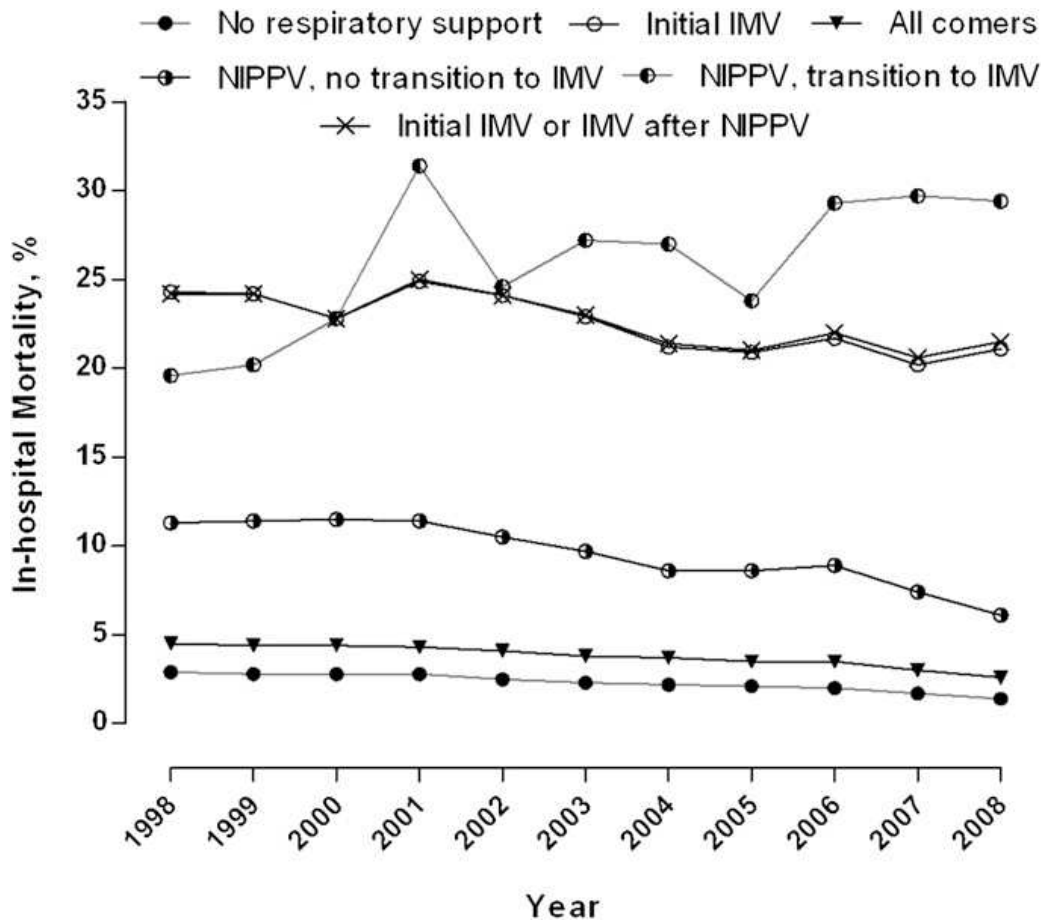
Clinical indication[#]	Certainty of evidence[¶]	Recommendation
Prevention of hypercapnia in COPD exacerbation	⊕⊕	Conditional recommendation against
Hypercapnia with COPD exacerbation	⊕⊕⊕⊕	Strong recommendation for
Cardiogenic pulmonary oedema	⊕⊕⊕	Strong recommendation for
Acute asthma exacerbation		No recommendation made
Immunocompromised	⊕⊕⊕	Conditional recommendation for
***De novo* respiratory failure**		No recommendation made
Post-operative patients	⊕⊕⊕	Conditional recommendation for
Palliative care	⊕⊕⊕	Conditional recommendation for
Trauma	⊕⊕⊕	Conditional recommendation for
Pandemic viral illness		No recommendation made
Post-extubation in high-risk patients (prophylaxis)	⊕⊕	Conditional recommendation for
Post-extubation respiratory failure	⊕⊕	Conditional recommendation against
Weaning in hypercapnic patients	⊕⊕⊕	Conditional recommendation for

[#]: all in the setting of acute respiratory failure; [¶]: certainty of effect estimates: ⊕⊕⊕⊕, high; ⊕⊕⊕, moderate; ⊕⊕, low; ⊕, very low.

Eur Respir J. 2017 Aug 31;50(2)

NIV to IMV vs IMV first





Am J Respir Crit Care Med. 2012 Jan 15;185(2):152-9.

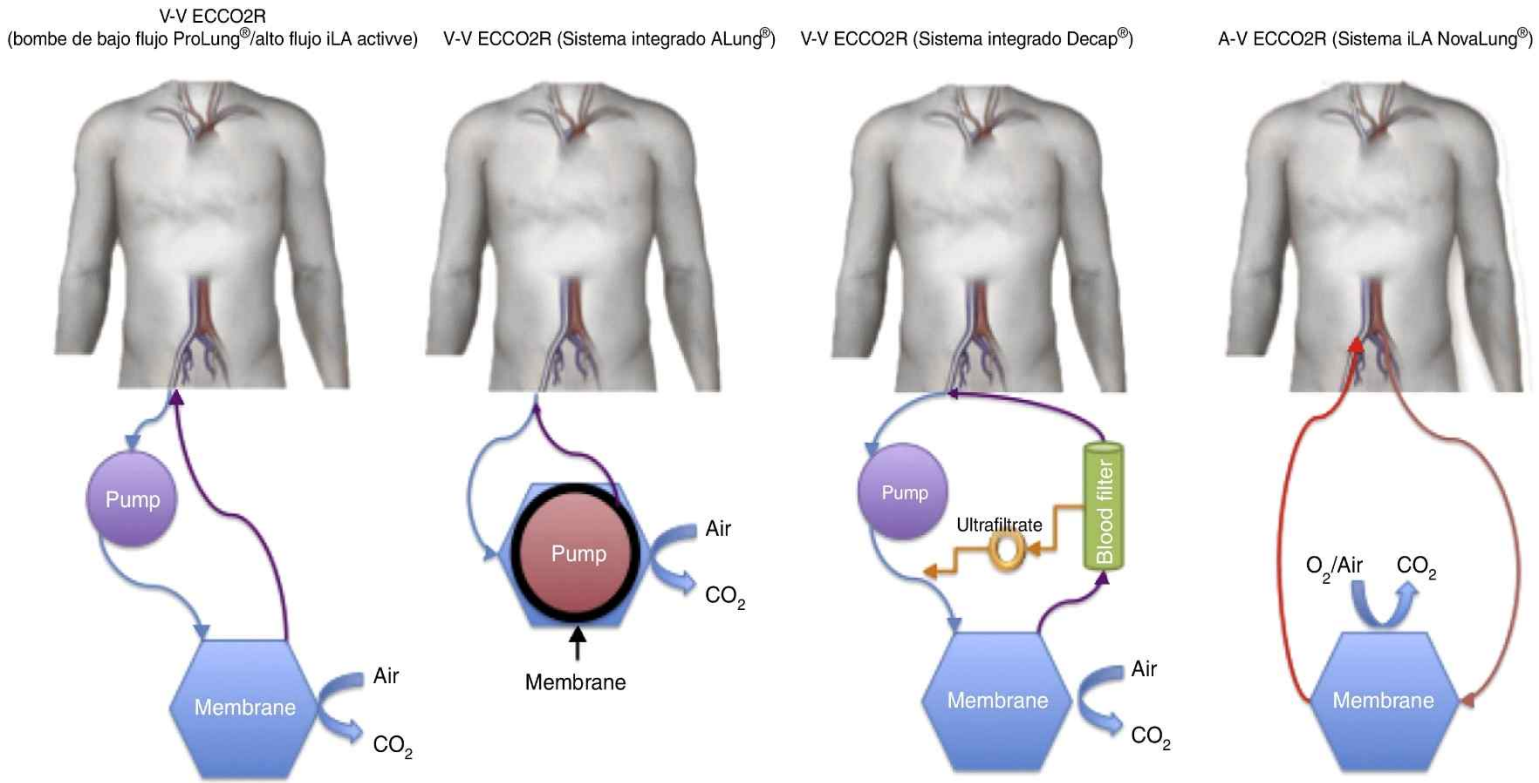
Indication for invasive MV in COPD AE

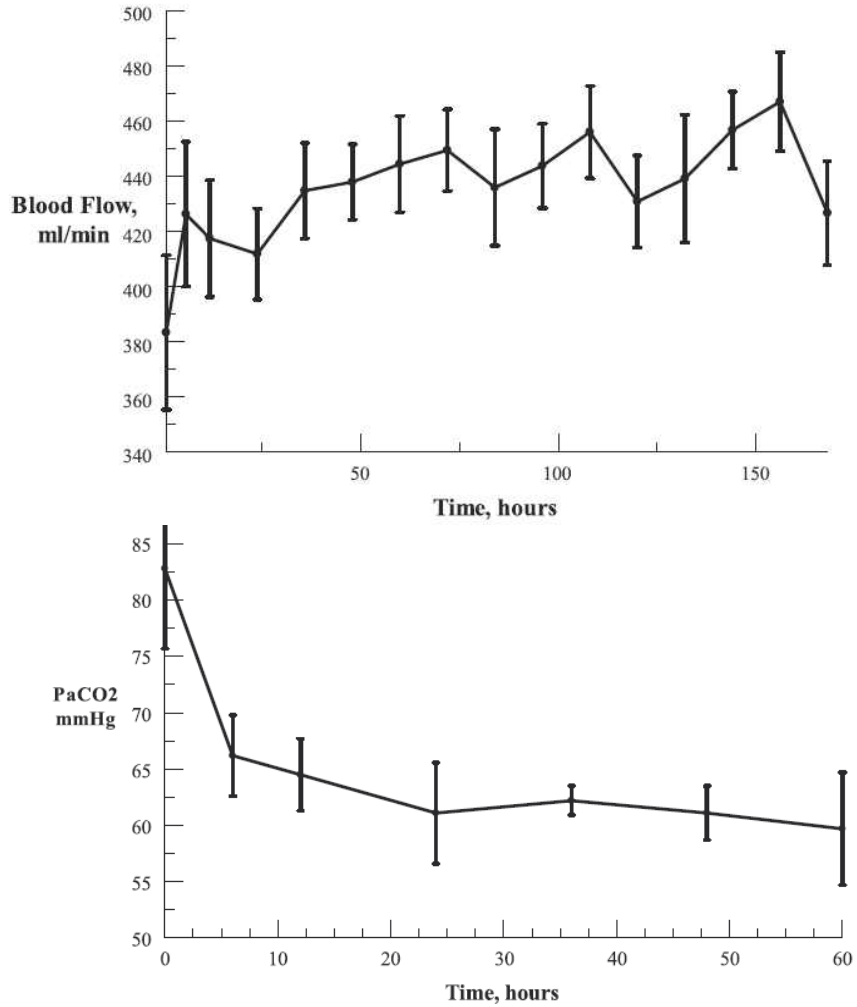
Box 1 Indications for invasive mechanical ventilation (IMV) in acute exacerbation of COPD (AECOPD)

- Imminent respiratory arrest
- Severe respiratory distress
- Failure of or contra-indications to non-invasive ventilation (NIV)
- Persisting pH<7.15 or deterioration in pH despite NIV
- Depressed consciousness (Glasgow Coma Score <8)

BTS/ICS guideline Thorax. 2016 Apr;71 :ii1-35.

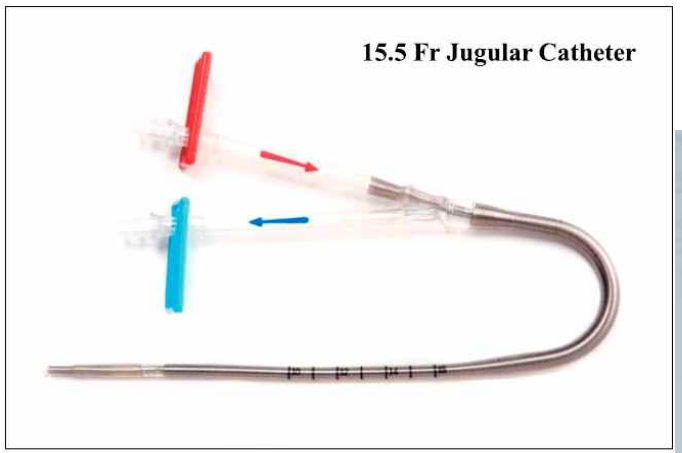
Not Intubated in COPD AE condition





CHEST 2013; 143(3):678–686

ECCO2R



Home NIV for COPD patients…

- With chronic hypercapnic respiratory failure
- To facilitate exercise capacity
- To promote pulmonary rehabilitation
- After acute respiratory failure
- In the future

Rationale

- In severe COPD, hypercapnia
  - V/Q mismatch or Dead space ventilation,
  - Respiratory muscle weakness:
    - Change in configuration of the diaphragm caused by hyperinflation, which puts the diaphragm at a mechanical disadvantage
    - Compromised nutrition, which is commonly encountered in severe COPD
    - Presumed "exhaustion" from the excessive resistive load imposed by the underlying disease

Am Rev Respir Dis. 1979;119(2 Pt 2):151.

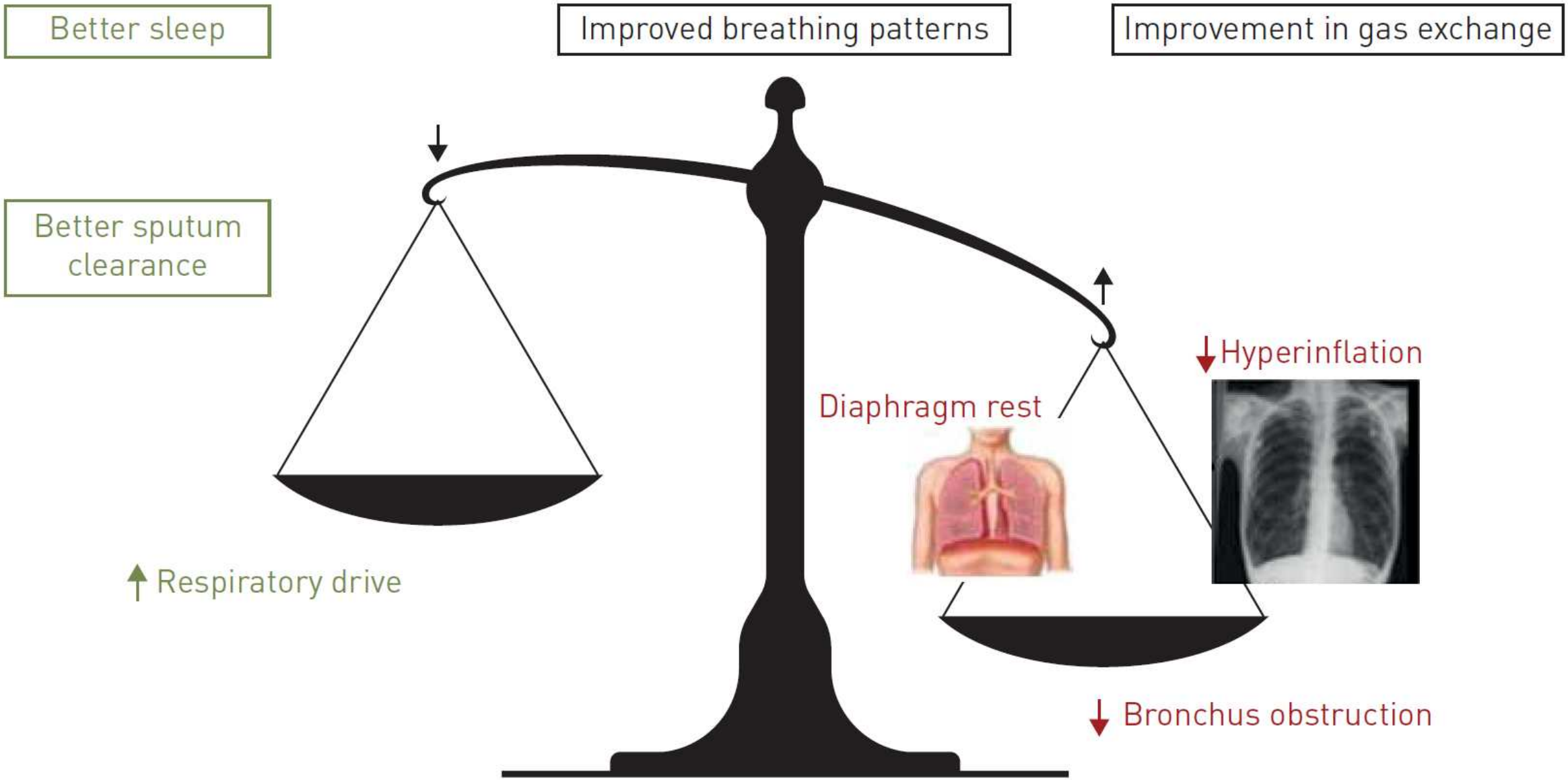


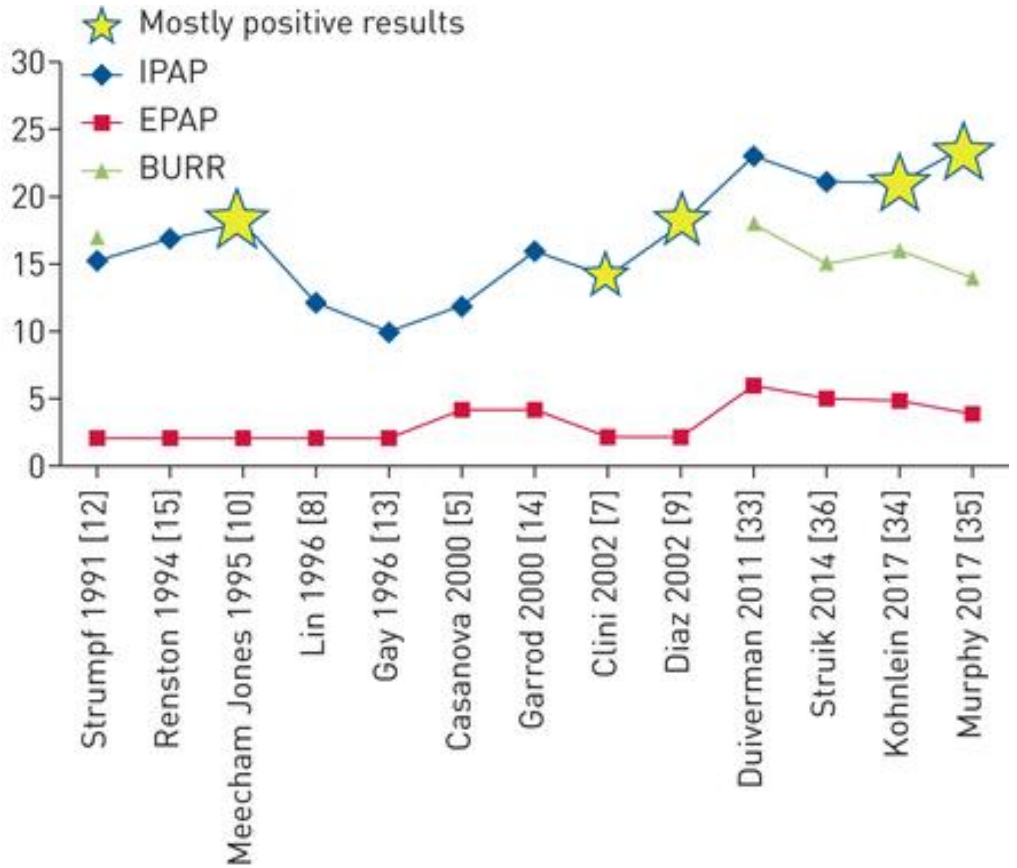
FIGURE 3 The influence of noninvasive ventilation (NIV) on the delicate balance between increased load and decreased capacity of the respiratory system in severe chronic obstructive pulmonary disease (COPD). The radiography image is reproduced from Radiology Assistant (www.radiologyassistant.nl) with permission.

Patient selection

- Nocturnal NIV
  - Daytime hypercapnia (eg, arterial carbon dioxide tension [$PaCO_2$] ≥52 mmHg),
  - Oxygen desaturation during sleep
    (eg, pulse oxygen saturation [SpO_2] ≤88 percent for ≥5 minutes of ≥2 hours of nocturnal sleep oximetry)
    despite the use of supplemental oxygen at ≥2 L/min,

Protocol for initiation in stable patients

- EPAP 2 → 4-6 cmH_2O / IPAP 6 → 12-20 cmH_2O (+2)
- High intensity NIV (normalize $PaCO_2$)
  - "low" IPAP (14 to 16 cm H_2O) with a "high" IPAP (25 to 30 cm H_2O)
    for 6 weeks and confirmed that the higher level was better tolerated
- FiO_2 increased only after ventilation(synchrony) improved.
  Goal is to achieve SpO_2 90 to 93 %
- Nasal to Facial mask



Int J Med Sci. 2009;6(2):72. Epub 2009 Feb 27.

Thorax. 2010;65(4):303.

Int J Chron Obstruct Pulmon Dis. 2012;7:811.

CO_2 target (Permissive Hypercapnia?)

Cerebral effects

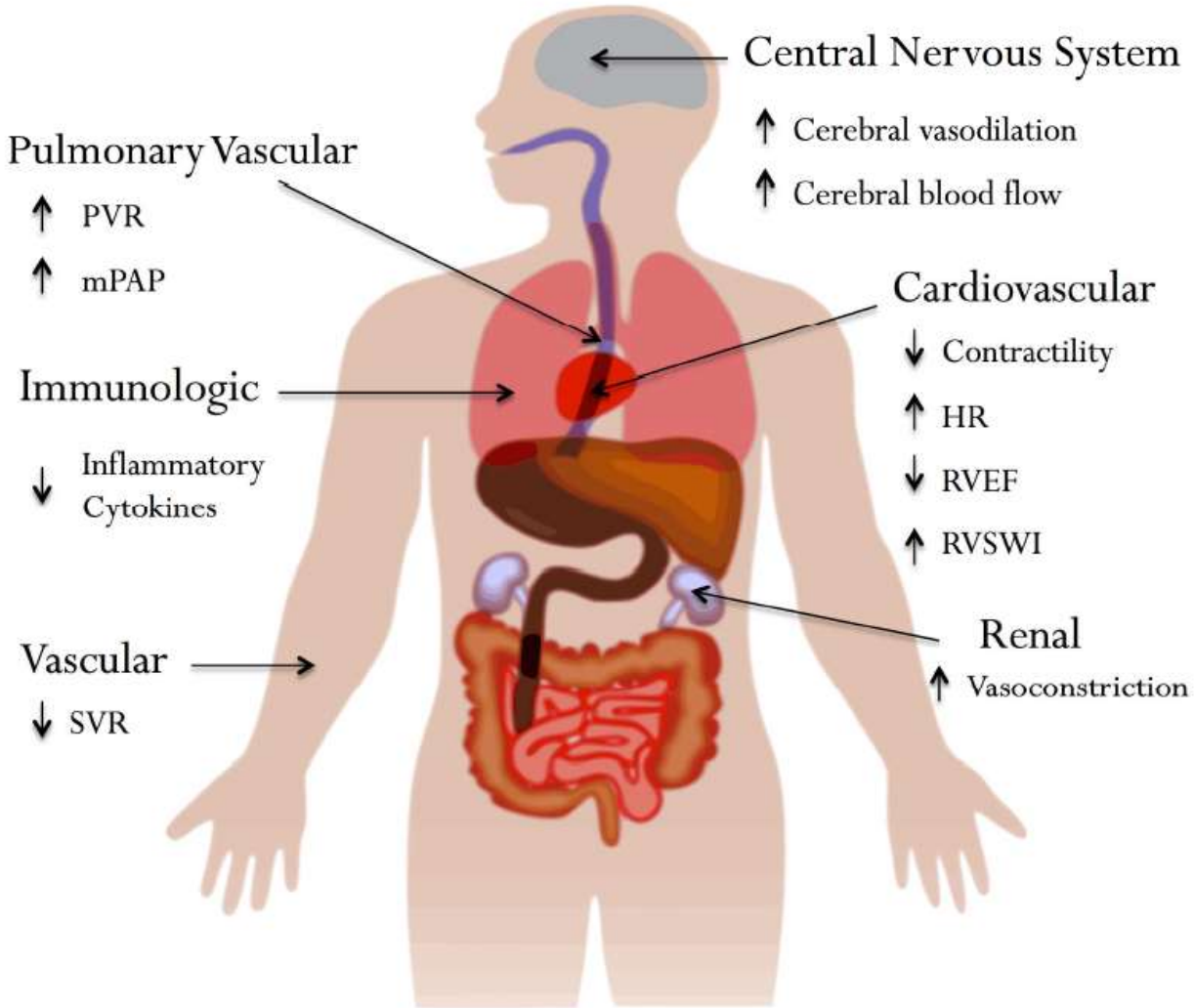
- An initial increase in respiratory drive followed by a depressed level of consciousness (also known as carb on dioxide [CO_2] narcosis) and reduced respiratory drive
- An increase in cerebral blood flow and intracranial pressure

Cardiorespiratory effects

- reduced myocardial and diaphragmatic contractility

Clinical effects of acidosis,

- cardiovascular instability/arrest, hypotension, and cerebral depression as well as decreased binding of calc ium to albumin (ie, increase serum ionized calcium levels) and an extracellular shift of potassium.



Chest. 2018 Jul;154(1):185-195.

- *Cytokine Response*
- *Inhibition of lung epithelial cell repair and function*
- *Renal effects*
- *Diaphragmatic and skeletal muscle effects*
- *Pulmonary circulation*
- *Buffered hypercapnic acidosis*

Monitoring

- Patient's acceptance of the device, level of dyspnea, oxygenation, and stability of vital signs.

- “High Intensity" pressure support aiming to reduce $PaCO_2$ or $tcCO_2$ by >4 mmHg

Treatment failure

- Patient intolerance, as indicated by patient request to discontinue nocturnal assisted ventilation.
- Worsening dyspnea, hemodynamic instability, or unresponsive hypoxemia.
- Signs of respiratory failure.
  Criteria for respiratory failure include tachypnea (respiratory rate >24/min) and respiratory acidosis (eg, pH <7.35).

AMERICAN THORACIC SOCIETY
DOCUMENTS

Long-Term Noninvasive Ventilation in Chronic Stable Hypercapnic Chronic Obstructive Pulmonary Disease

An Official American Thoracic Society Clinical Practice Guideline

1. We suggest the use of nocturnal noninvasive ventilation (NIV) in addition to usual care for patients with chronic stable hypercapnic COPD (conditional recommendation, moderate certainty).
2. We suggest that patients with chronic stable hypercapnic COPD undergo screening for obstructive sleep apnea before initiation of long-term NIV (conditional recommendation, very low certainty).
3. We suggest not initiating long-term NIV during an admission for acuteon-chronic hypercapnic respiratory failure, favoring instead reassessment for NIV at 2–4 weeks after resolution (conditional recommendation, low certainty).
4. We suggest not using an in-laboratory overnight polysomnogram (PSG) to titrate NIV in patients with chronic stable hypercapnic COPD who are initiating NIV (conditional recommendation, very low certainty).
5. We suggest NIV with targeted normalization of PaCO2 in patients with hypercapnic COPD on long-term NIV (conditional recommendation, low certainty).

Issues to Consider

- Appropriate patient selection.
- Implementation barriers.
- The need for more data to guide the goals of therapy, especially on how clinicians should target $PaCO_2$.
- Addressing regulatory/payor considerations on the ability to obtain home NIV for COPD.
- The potential for worsening health care disparities due to the cost and expertise needed to provide NIV for patients with stable hypercapnic COPD.

UNIKLINIK RWTH AACHEN

Dreher M. et al.
Respiration. 2009;78(2):154-60

Dreher M. et al.
Eur Respir J 2007; 29: 930-936

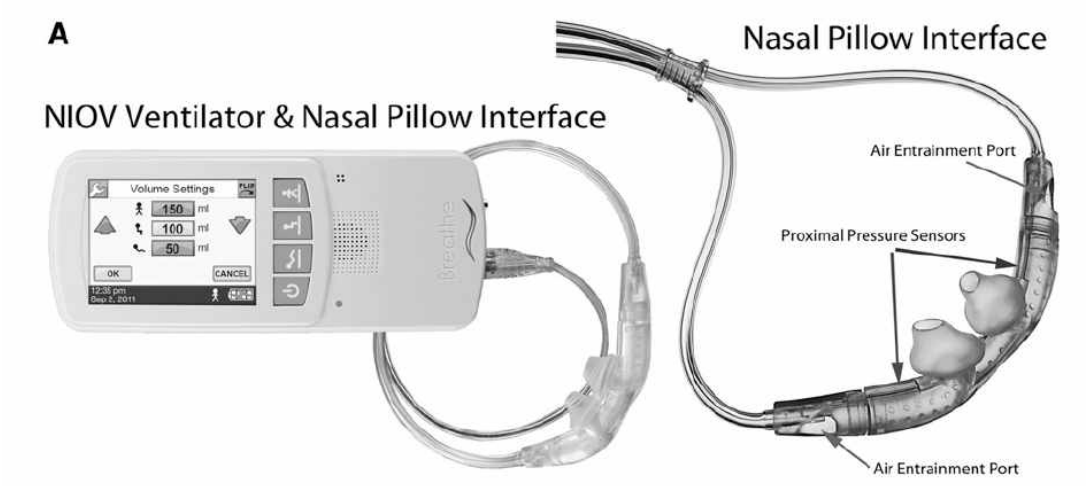
Dreher M. et al.
Respiration 2010;80(2):106-111

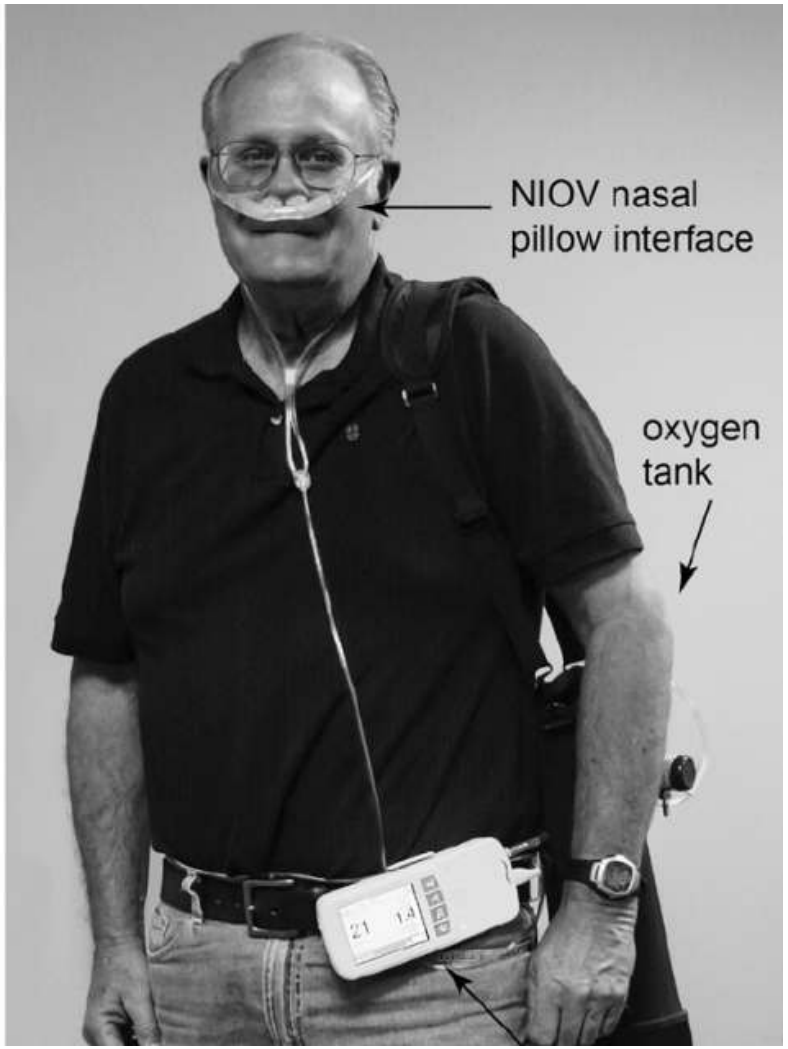
Physical Training and Noninvasive Ventilation in COPD Patients: A Meta-Analysis

Ricci et al. Respir Care. **2014** May;59(5):709-17

Given the **small number of available studies**, the **small sample sizes**, and the **complete absence of power calculation**, we think that **this topic deserves a more in-depth investigation**. Randomized clinical trials with larger sample sizes based on statistical power calculations and designed to investigate the effect of training duration and intensity on rehabilitation are needed to confirm results in this important field.

Physiologic Effects of an Ambulatory Ventilation System in Chronic Obstructive Pulmonary Disease





Am J Respir Crit Care Med 2013:3 :334

Tuberculosis and Respiratory Diseases 결핵 및 호흡기질환, Vol. 49, No. 5, Nov, 2000
□원 저□

가정용 인공호흡기를 사용하는 서울 및 경기 지역 환자의 실태

울산대학교 의과대학 울산대학교 병원* 및 서울중앙병원 호흡기내과

안종준*, 이기만*, 심태선, 임채만, 이상도
김우성, 김동순, 김원동, 고윤석

Table 2. Underlying diseases of patients

Underlying diseases	No of patients	%
Neuromuscular disorder		
Amyotrophic lateral sclerosis	15	51.7
Cerebral palsy	3	10.3
Postpoliomyelitis	1	3.5
Muscular dystrophy	2	6.9
Spinal cord injury	2	6.9
Chronic lung disease		
COPD	4	13.8
Tuberculous destroyed lung	2	6.9
Total	29	100

25명/29명 : tracheostomy
4명/29명 : NIV

전혀 의사/장비업체와 접촉하지 않은 경우: 5명

병원과 어떤 식으로든 연결되는 환자 20명 (69%)

7명중 4명에서 산소를 중단 후 산소 포화도 : 95%

가정용 인공호흡기를 사용하는 서울 및 경기 지역 환자의 실태

간호 관리: 배우자 14명/29명 (48.3%)
관리에 소요되는 시간: 24시간(24명/29명)

분비물 흡인 교육: 2명은 사전 교육을 전혀 받지 않음
인공호흡기 교육: 20명이 회사직원 4명 의사 2명 간호사 3명 전혀 배우지 못함
경관식 교육 : 3명 전혀 배우지 못함

결핵 및 호흡기질환, Vol. 49, No. 5, Nov, 2000

Statistics

2016-10-01 - 2016-12-22

Device Settings

Therapy Mode: Volume assured pressure support mode

Pressure: **5.0 cmH2O**

Target Patient Rate: **19.0 bpm**

Rise Time: **150.0**

Fall Time: **200.0**

Trigger Sensitivity: **MED**

Cycle Sensitivity: **HIGH**

Ti Max: **1.0 sec**

Ti Min: **0.3 sec**

Max PS: **20.0 cmH2O**

Min PS: **4.0 cmH2O**

Target Alveolar Ventilation: **7.4 L/min**

Height: **155.0 cm**

Pressure Support - cmH2O

5th Percentile: **17.7**

Median: **20.0**

95th Percentile: **20.0**

IPAP - cmH2O

5th Percentile: **22.8**

Leak - L/min

5th Percentile: **7.0**

Tidal Volume - mL

5th Percentile: **220**

Minute Ventilation - L/min

5th Percentile: **4.2**

Respiratory Rate - breaths/m

5th Percentile: **19**

% Spontaneous triggered bre

Respiratory Indices - events/h

Apnea Index: **0.0**

Hypopnea Index: **1.3**

AHI: **1.3**

Total Usage

Used Days >= 4 hrs : **74**

Used Days < 4 hrs : **9**

% Used Days >= 4 hrs : **89**

Days not used: **0**

Total days: **83**

Total hours used: **501:26**

Median daily usage: **6:14**

Average daily usage: **6:02**

I:E Ratio

5th Percentile: **1:2.5**

Median: **1:2.17**

95th Percentile: **1:2.17**

Inspiratory Time - seconds

5th Percentile: **1.00**

Median: **1.00**

95th Percentile: **1.00**

Alveolar Ventilation - L/min

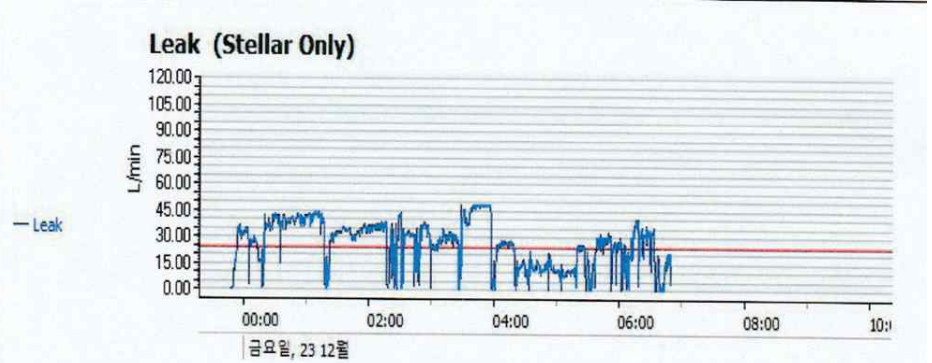
5th Percentile: **2.5**

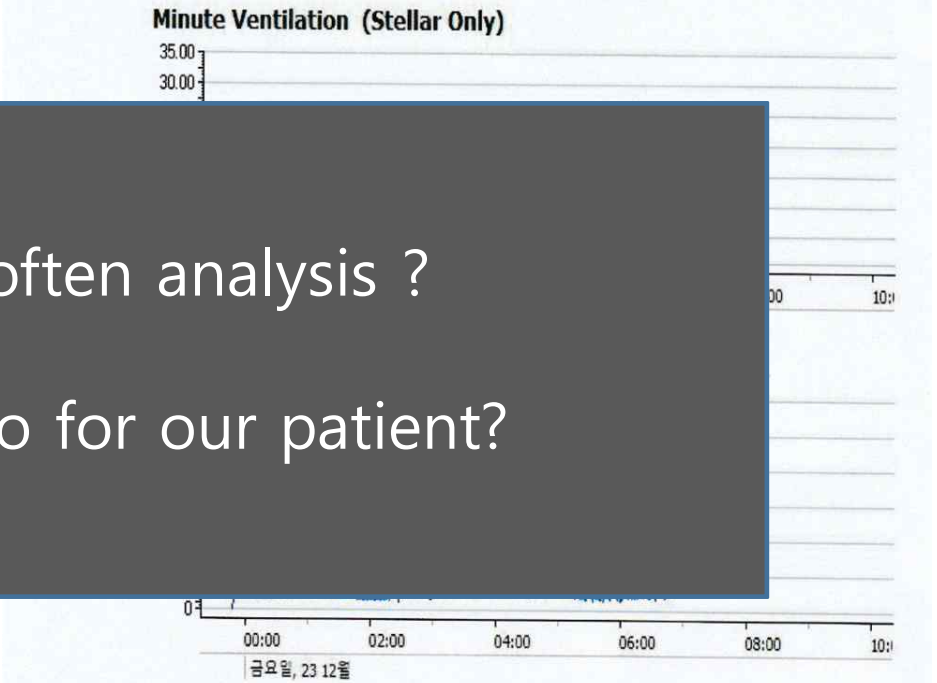
Median: **4.6**

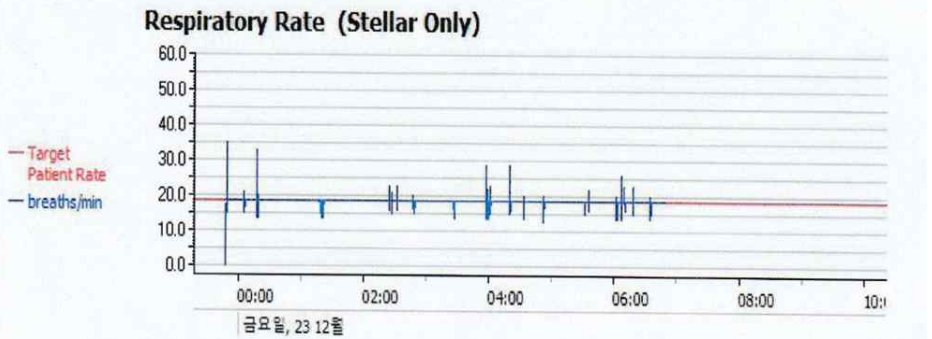
95th Percentile: **8.1**

How do we often analysis ?

What shall we do for our patient?

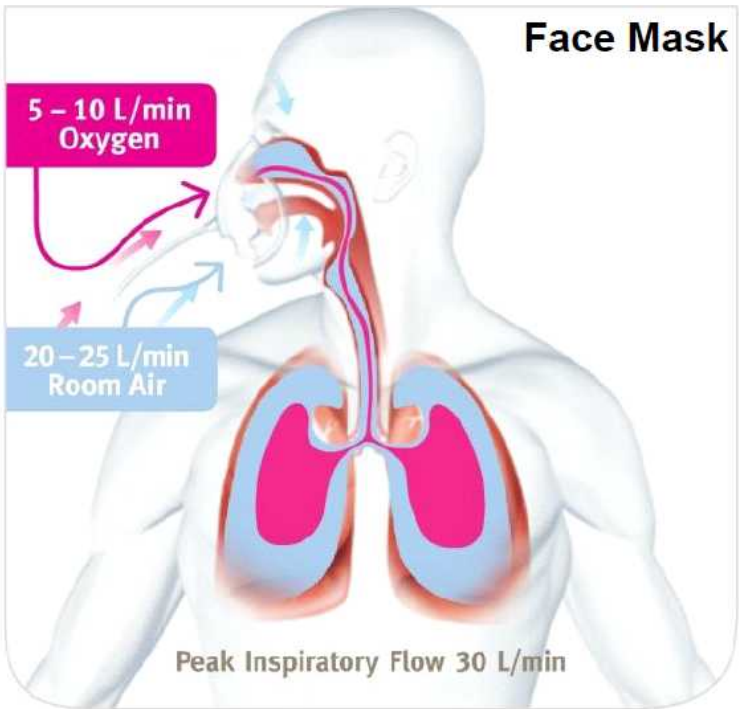


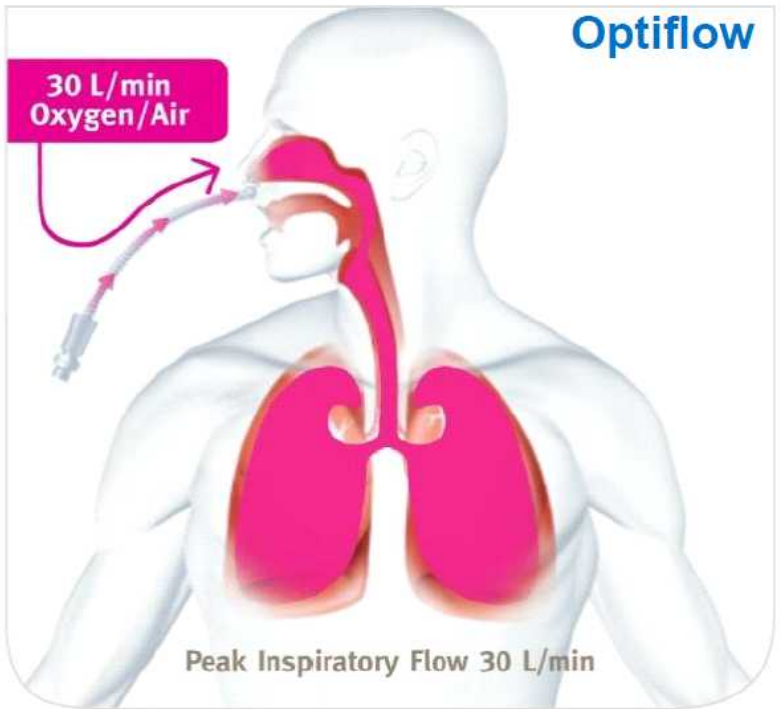




Nasal High Flow Oxygen Therapy in COPD

1. Accurate FiO_2 delivery





By Fisher & Paykel Healthcare

2. Anatomical Dead space ↓

상기도에 고유량 산소의 지속적인 공급 효과

고유량 산소 공급으로 상기도 **Washout**

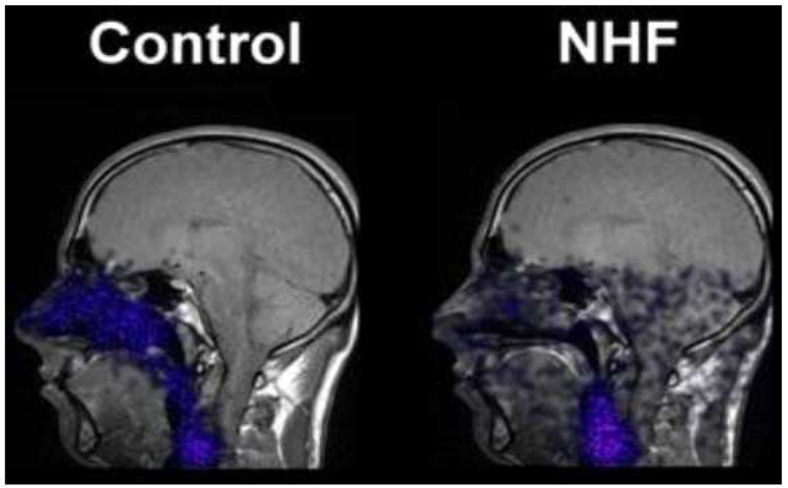
비인두의 CO_2 재호흡 감소

Dead space volume 감소

폐포 환기 증진

Work of Breathing 감소

Oxygenation ↑

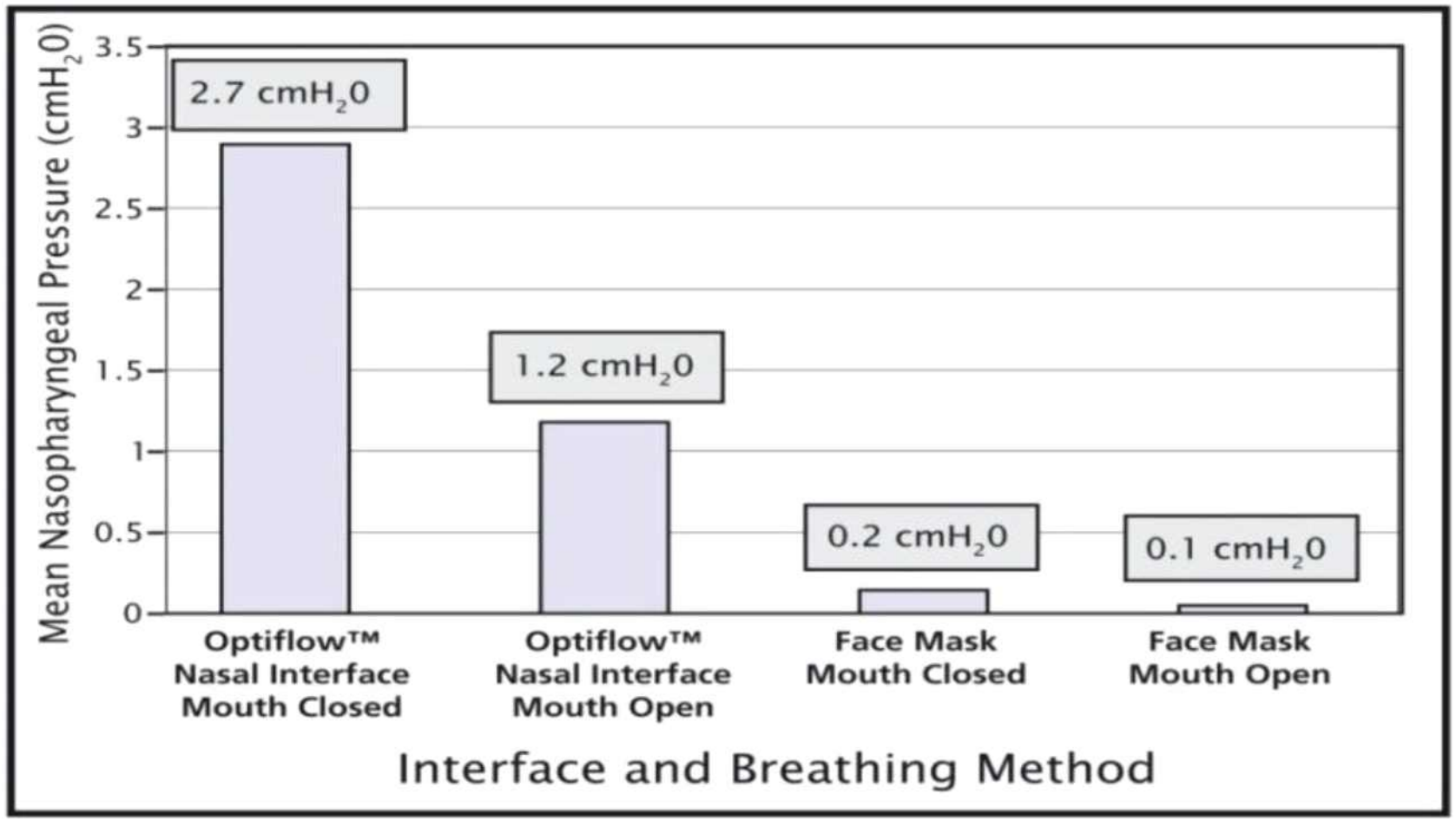


Stereoscopic PIV measurements of flow in the nasal cavity with high flow therapy

C. J. T. Spence · N. A. Buchmann · M. C. Jermy · S. M. Moore

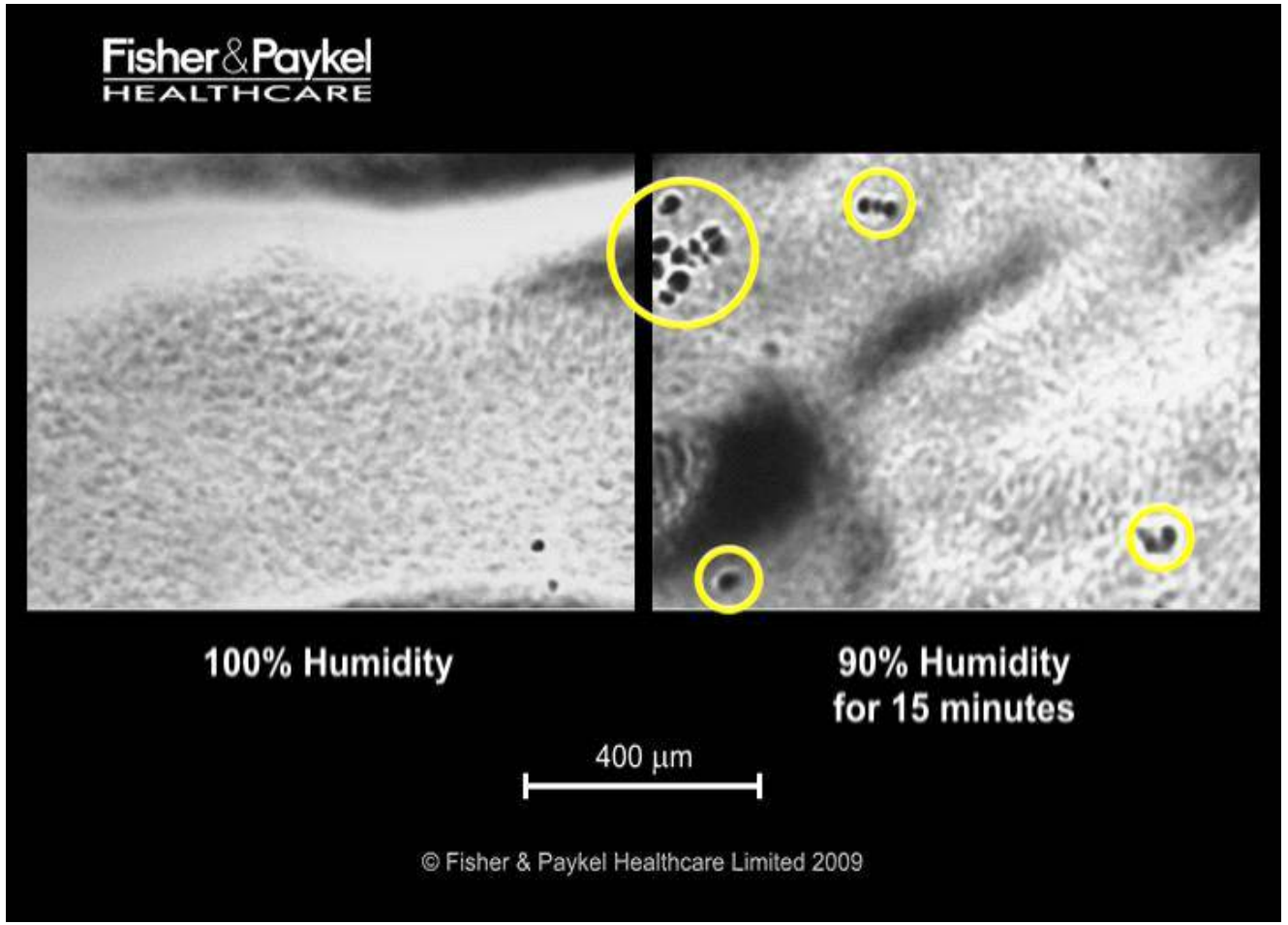
By Fisher & Paykel Healthcare

3. Positive Airway pressure



Comparison of Interface & Breathing Method at **35 L/min**

4. Heated & Humidified

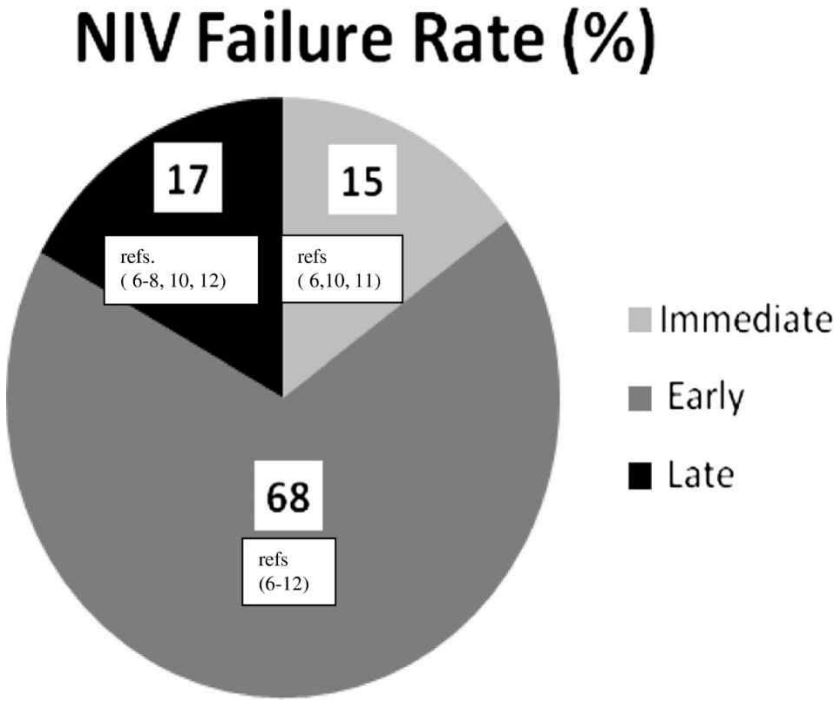


Optimized Mucociliary Clearance: Video microscopy of an ovine tracheal sample:

5. Patient's Comfort

- Major cause of NIV Failure; 5-60%

- Early Failure
  - P/F < 150
  - SAPS II >35
  - ARDS, Pneumonia, Sepsis, MOF (OR:4-28)
  - RR>25

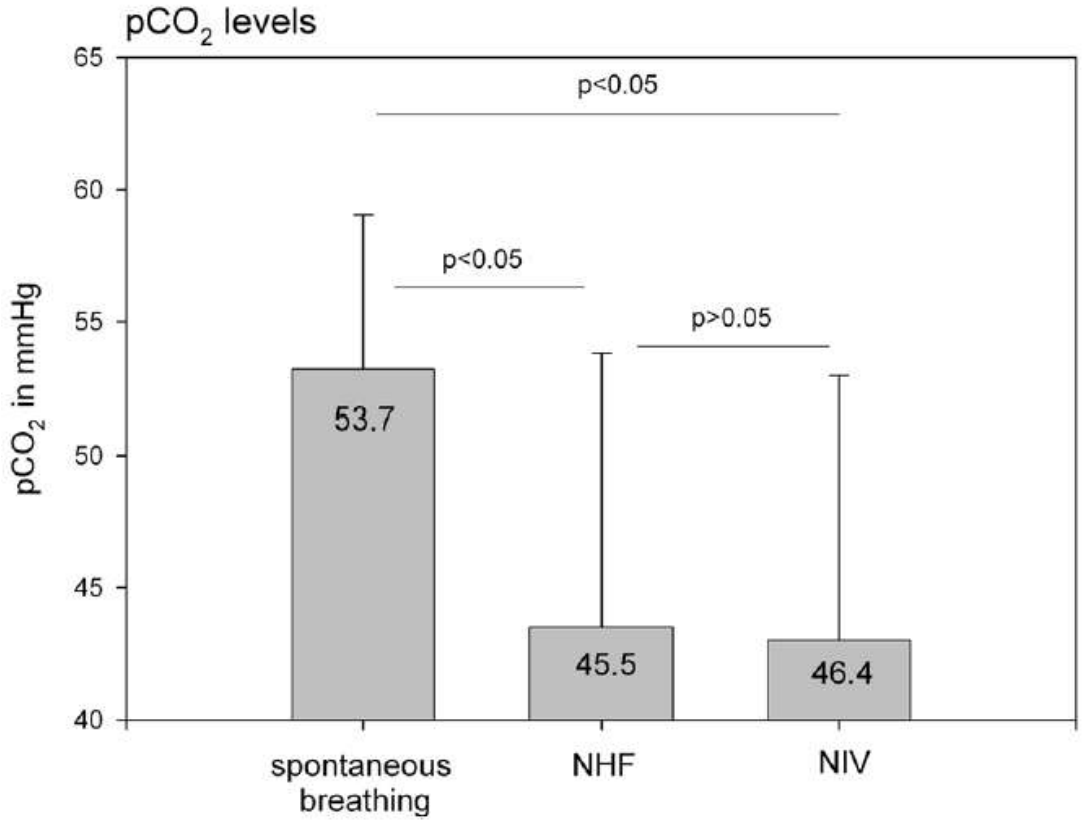


1) Immediate failure (within 1 h),
2) Early failure (1 to 48 h),
3) Late failure (after 48 h)

*BMC Pulmonary Medicine*2014 **14**:19

First studies of Nasal High Flow in COPD

- 11 patients with stable COPD
- 6 weeks of nasal high flow (20L/min)
- 6 weeks NIV



Multidisciplinary Respiratory Medicine (2015) 10:27

Stable home oxygen-dependent COPD patients

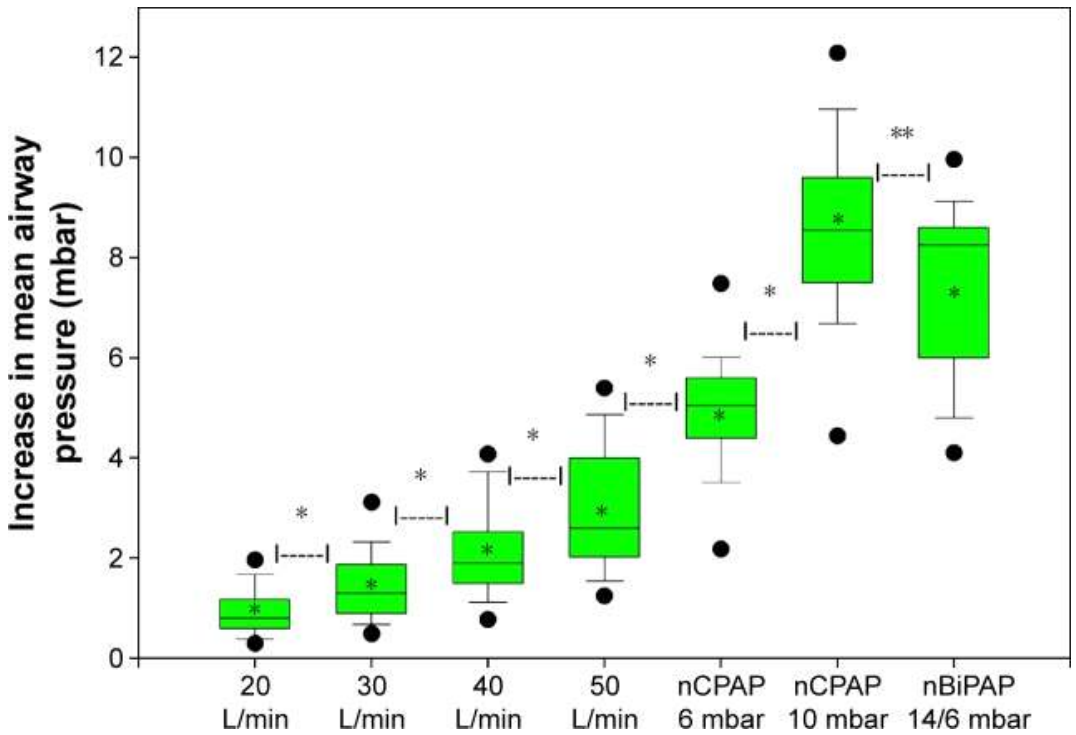
- 30 patients with long term oxygen therapy:
  - 20 min with nasal high flow (30L/min)
  - 20 min with conventional oxygen (2-4L/min)

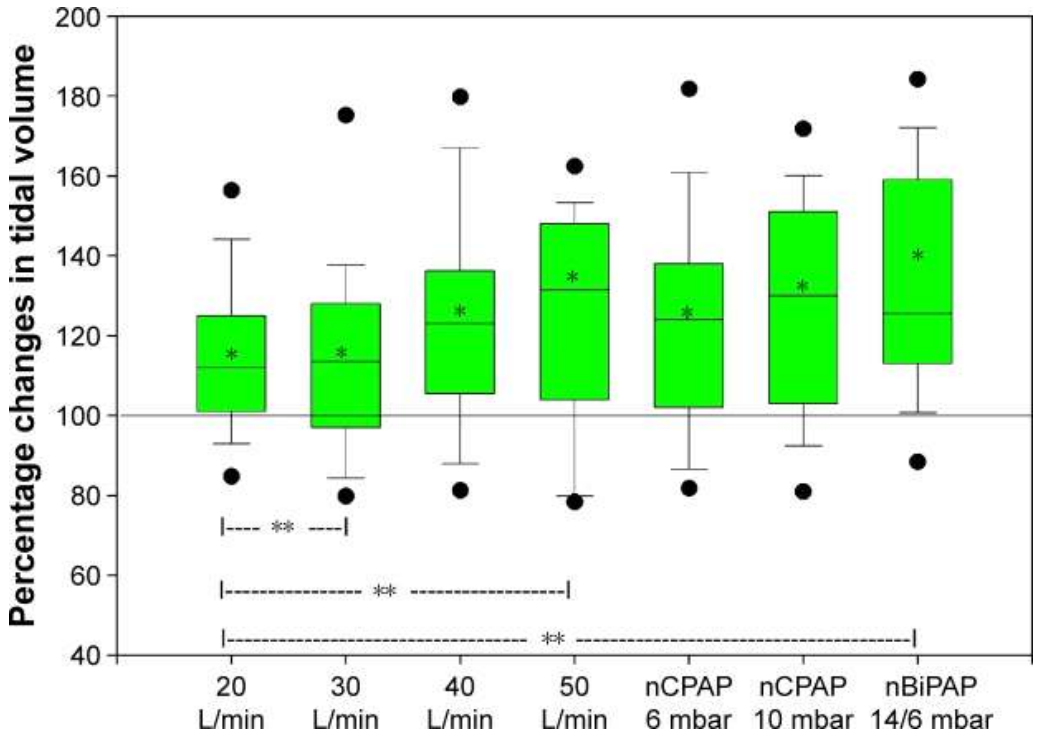
Table 1 Two-way (paired) comparisons between the long-term oxygen therapy (LTOT) and nasal high flow (NHF) groups

Variable	LTOT	NHF	p Value
Oxygen saturation (%)*	95.8 (94.6 to 96.9)	95.7 (93.1 to 97.1)	0.06
Transcutaneous O_2 (mm Hg)	101.2 (22.5)	97.1 (24.2)	0.01
Transcutaneous CO_2 (mm Hg)	46.7 (9.4)	43.3 (9.5)	<0.001
Respiratory rate (breaths/min)	19.2 (6.3)	15.4 (4.8)	0.001
Inspiratory:expiratory ratio	0.86 (0.20)	0.75 (0.25)	0.02
Tidal volume (L)*	0.40 (0.34, 0.46)	0.50 (0.41, 0.54)	0.003
Minute volume (L/min)*	6.20 (4.84, 8.18)	6.18 (4.75, 7.69)	0.88
Heart rate (beats/min)	70.1 (59.1, 79.3)	69.8 (61.3, 79.8)	0.21
End-expiratory lung impedance (%Δ)*	113 (98, 128)	174 (161, 187)	<0.001

Thorax. 2016 Aug;71(8)

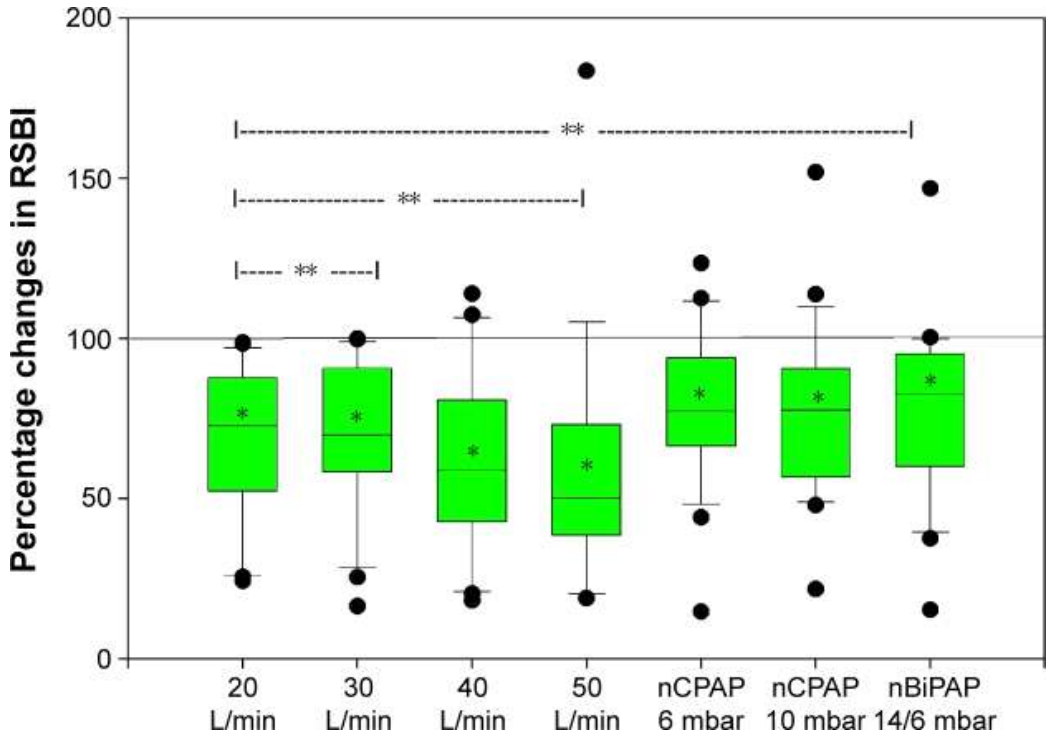
Nasal highflow improves ventilation in patients with COPD (GOLD C/D, No AE)





Int J Chron Obstruct Pulmon Dis. 2016; 11: 1077–1085.

Open up the possibility to compare NHF and NIV in COPD AE



Comfort/dyspnea scale

	NHF small	NHF medium	NHF large	nCPAP	nBiPAP
Comfort scale (1–10)					
Mean ± SD	4.3±1.5	3.4±1.5	3.9±2.0	5.4±1.9	4.4±2.4
P-value	<0.05		>0.05	<0.01	>0.05
Dyspnea scale (1–5)					
Mean ± SD	2.7±0.7	2.6±0.9	2.6±0.9	3.2±0.7	2.8±1.1
P-value	>0.05		>0.05	<0.01	>0.05

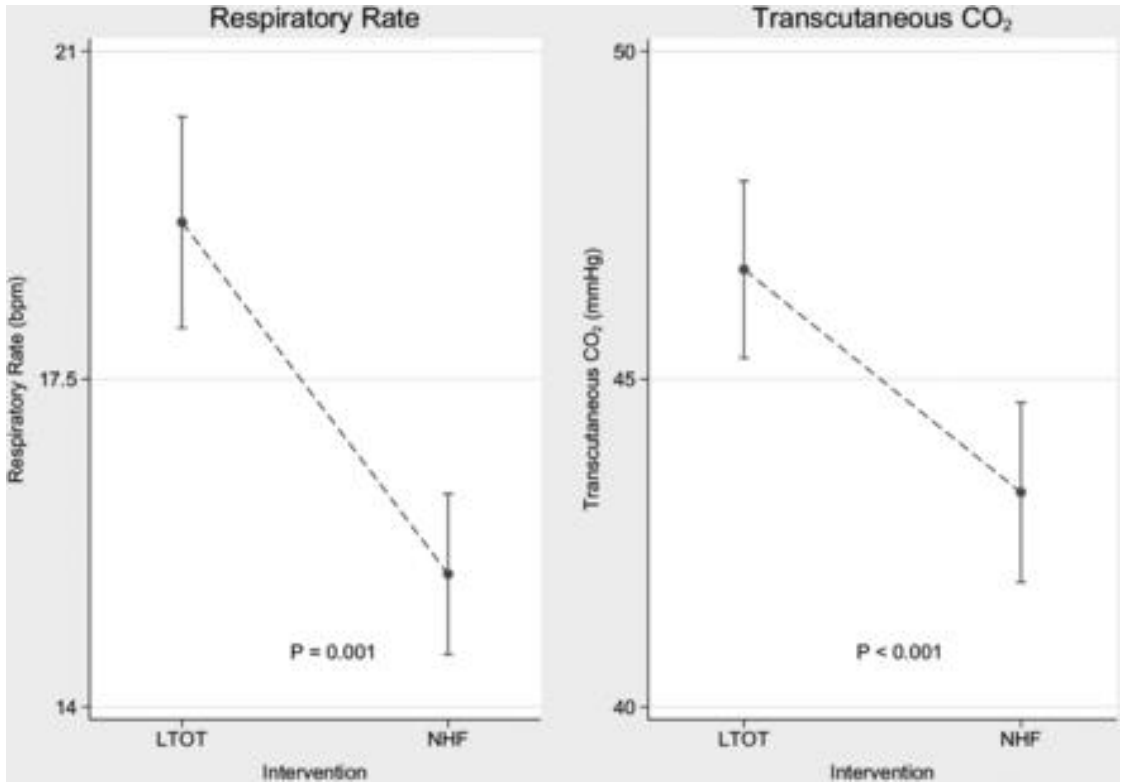
Int J Chron Obstruct Pulmon Dis. 2016; 11: 1077–1085.

vs long-term oxygen therapy

LTOT(2–4 L/min) vs NHF(30 L/min)

Cross-over (20min-20min-20min)

- Tidal volume (Vt)
  (0.50 vs 0.40, p=0.003)
- End-expiratory lung volume (EELV)
  (174% vs 113%, p<0.001)
- Subjective dyspnoea and interface comfort
  LTOT > NHF



Thorax. 2016 Aug;71(8):759-61

Type2 Respiratory Failure in COPD

- Pts with CIx to NIV

	Initial VBG	Normalized VBG	Time to normalization
Patient 1	pH 7.16; pCO_2 80; HCO_3^- 20	ph 7.35; pCO_2 50; HCO_3^- 26	16h
Patient 2	pH 7.27; pCO_2 100; HCO_3^- 32	pH 7.38; pCO_2 68; HCO_3^- 34	20h
Patient 3	pH 7.19; pCO_2 80; HCO_3^- 22	pH 7.36; pCO_2 40; HCO_3^- 22	3h
Patient 4	pH 7.18; pCO_2 74; HCO_3^- 18	pH 7.36; pCO_2 48; HCO_3^- 24	4h

- Present evidence for NHF is still anecdotal

- Worth trying in desperate cases where no other option is possible.

Respir Med Case Rep. 2017; 20: 87–88.

HFNC vs NIV in COPD AE - RCT in Korea

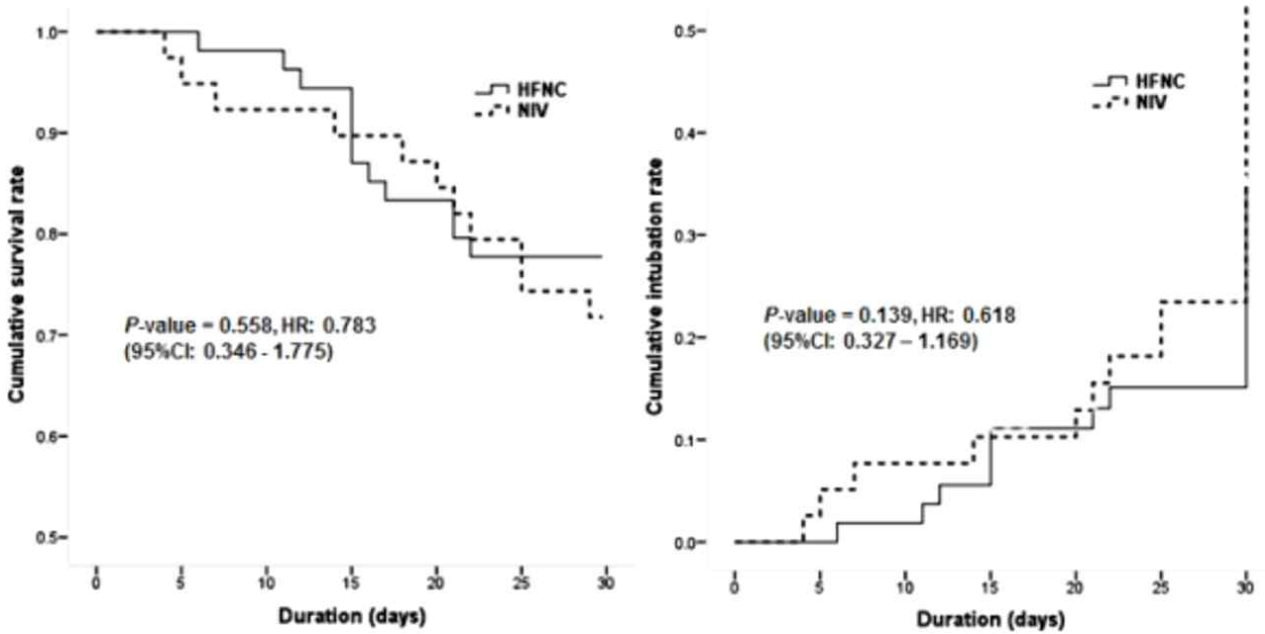


Figure 1. Cumulative survival rate between HFNC and NIV oxygen therapy

Figure 2. Cumulative intubation rate between HFNC and NIV oxygen therapy

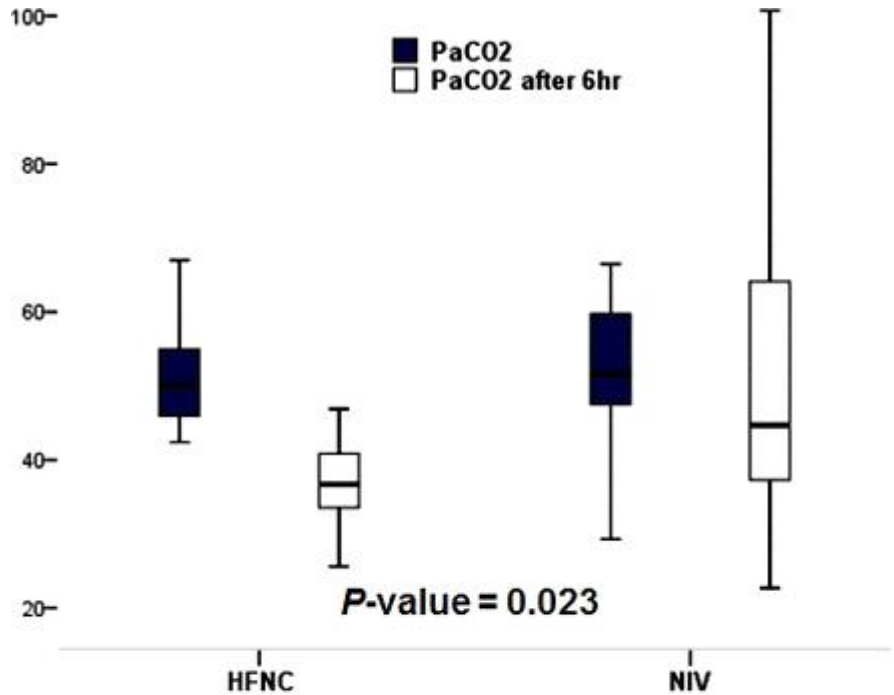
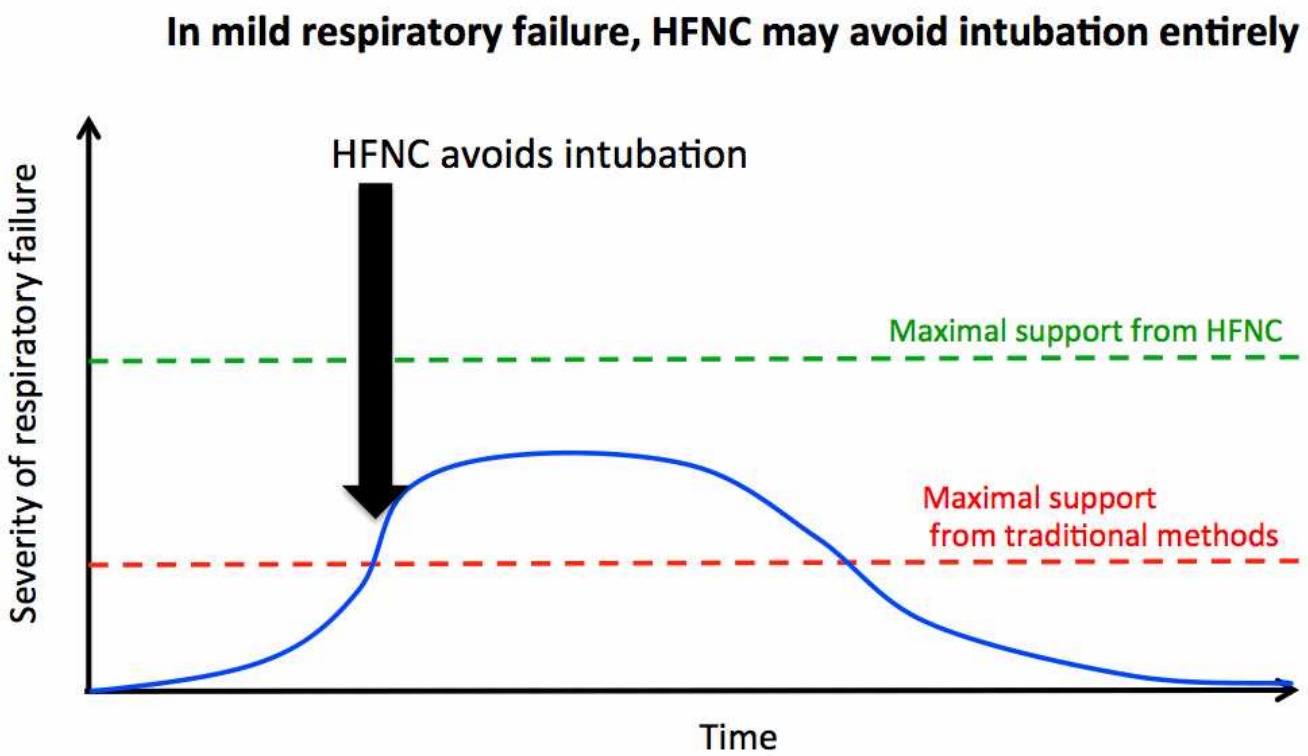


Figure 1. $PaCO_2$ after 6 hours between HFNC and NIV oxygen therapy

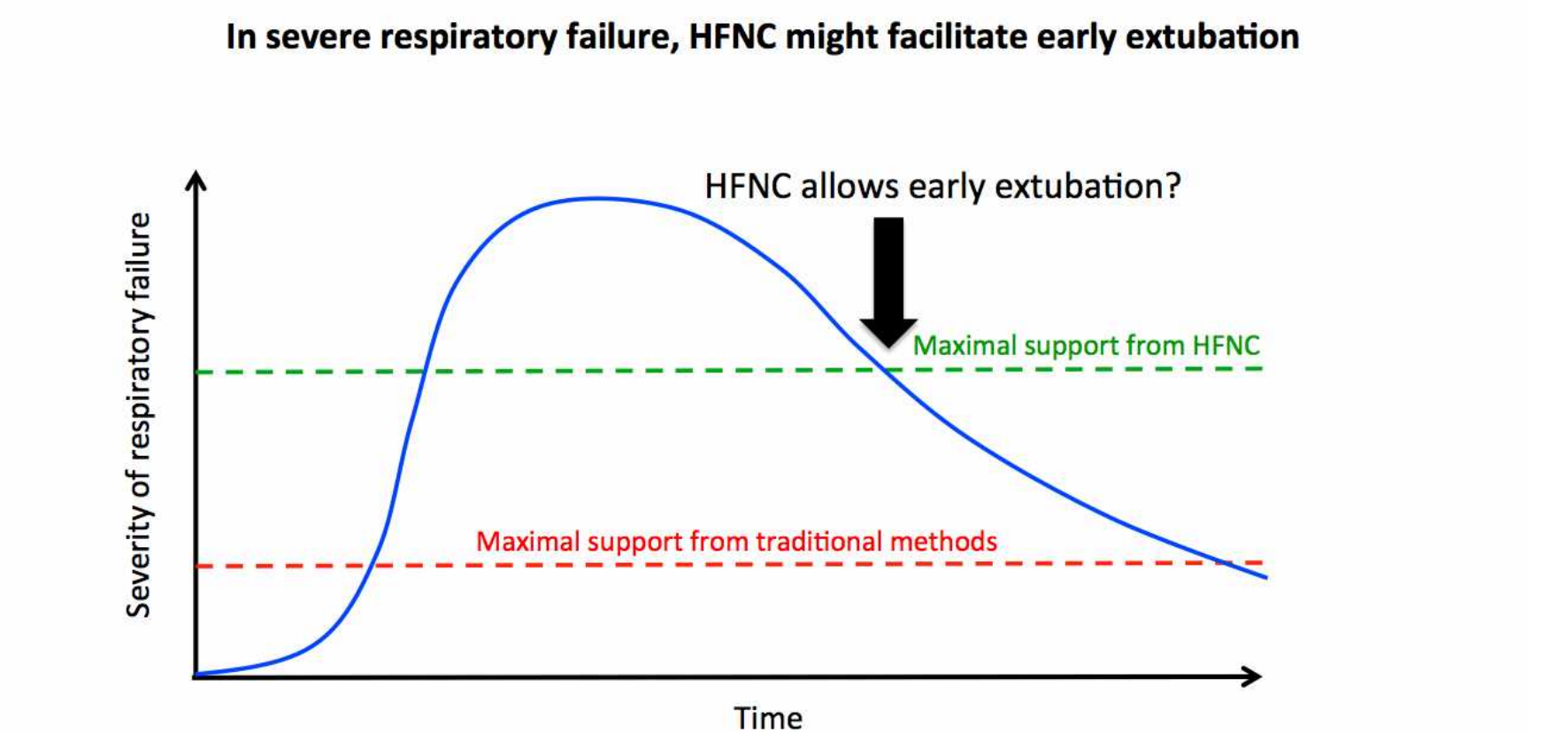
European Respiratory Journal 2016 48: PA3058

Role of HFNC in Respiratory Failure



http://emcrit.org/pulmcrit/proposal-early-ventilator-weaning-to-hfnc-in-hypoxemic-respiratory-failure/

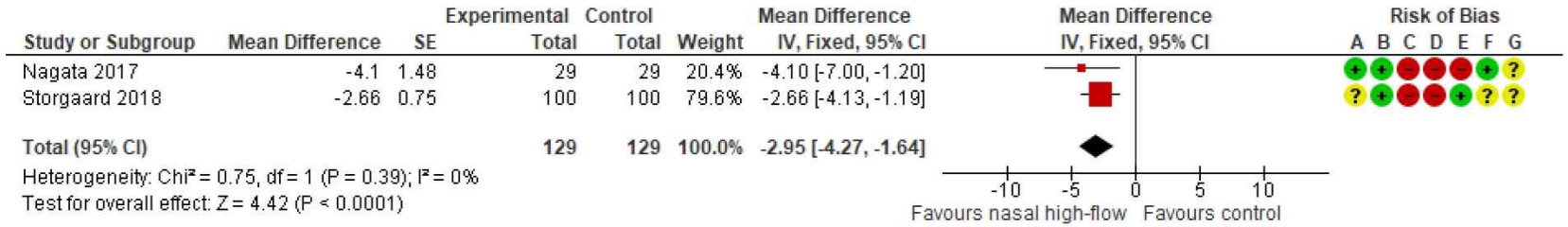
Role of HFNC in Respiratory Failure



http://emcrit.org/pulmcrit/proposal-early-ventilator-weaning-to-hfnc-in-hypoxemic-respiratory-failure/

HFNC - CO_2 removal for stable COPD

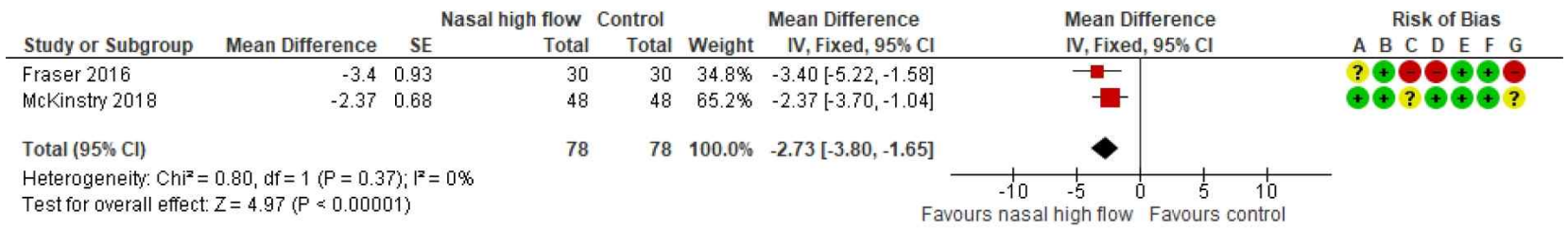
A



Study or Subgroup	Mean Difference	SE	Experimental Total	Control Total	Weight	Mean Difference IV, Fixed, 95% CI
Nagata 2017	-4.1	1.48	29	29	20.4%	-4.10 [-7.00, -1.20]
Storgaard 2018	-2.66	0.75	100	100	79.6%	-2.66 [-4.13, -1.19]
Total (95% CI)			**129**	**129**	**100.0%**	**-2.95 [-4.27, -1.64]**

Heterogeneity: Chi² = 0.75, df = 1 (P = 0.39); I² = 0%
Test for overall effect: Z = 4.42 (P < 0.0001)

B



Study or Subgroup	Mean Difference	SE	Nasal high flow Total	Control Total	Weight	Mean Difference IV, Fixed, 95% CI
Fraser 2016	-3.4	0.93	30	30	34.8%	-3.40 [-5.22, -1.58]
McKinstry 2018	-2.37	0.68	48	48	65.2%	-2.37 [-3.70, -1.04]
Total (95% CI)			**78**	**78**	**100.0%**	**-2.73 [-3.80, -1.65]**

Heterogeneity: Chi² = 0.80, df = 1 (P = 0.37); I² = 0%
Test for overall effect: Z = 4.97 (P < 0.00001)

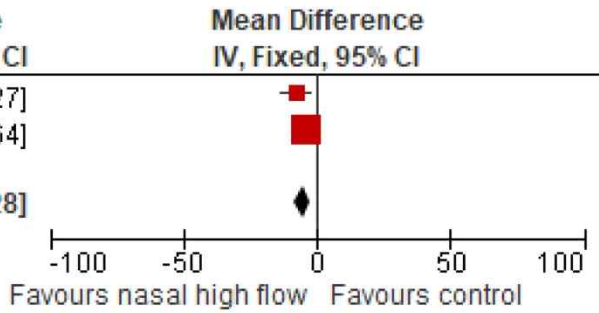
Risk of bias legend
(A) Random sequence generation (selection bias)
(B) Allocation concealment (selection bias)
(C) Blinding of participants and personnel (performance bias)
(D) Blinding of outcome assessment (detection bias)
(E) Incomplete outcome data (attrition bias)
(F) Selective reporting (reporting bias)
(G) Other bias

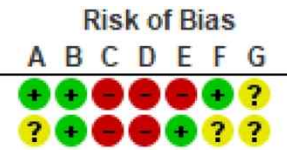
COPD. 2019 Dec;16(5-6):368-377.

HFNC - QoL for stable COPD

Study or Subgroup	Mean Difference	SE	Nasal high flow Total	Control Total	Weight	Mean Difference IV, Fixed, 95% CI
Nagata 2017	-7.8	2.82	29	29	29.6%	-7.80 [-13.33, -2.27]
Storgaard 2018	-4.23	1.83	100	100	70.4%	-4.23 [-7.82, -0.64]
Total (95% CI)			**129**	**129**	**100.0%**	**-5.29 [-8.30, -2.28]**

Heterogeneity: Chi² = 1.13, df = 1 (P = 0.29); I² = 11%
Test for overall effect: Z = 3.44 (P = 0.0006)





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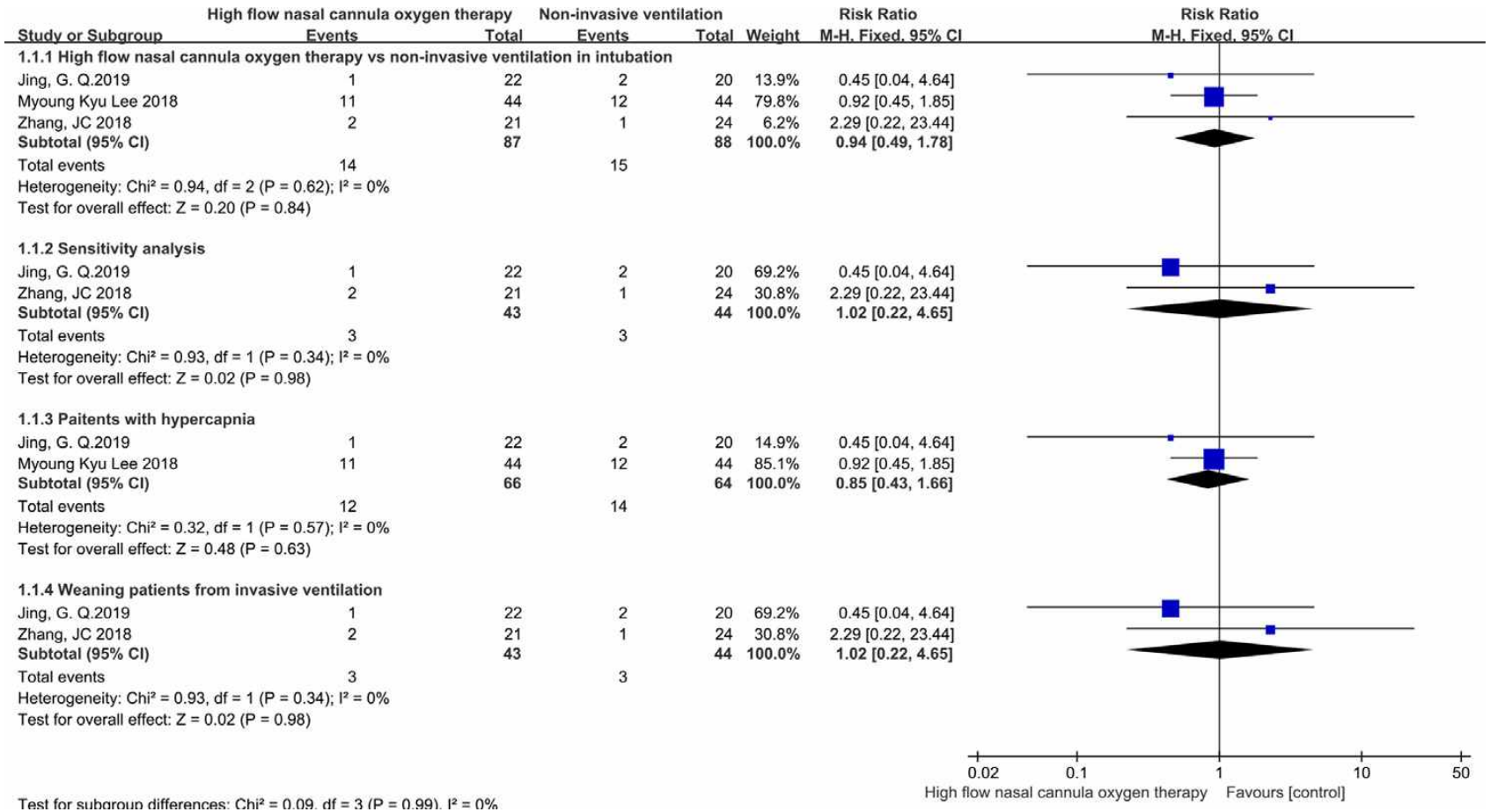
(G) Other bias

COPD. 2019 Dec;16(5-6):368-377.

HFNC vs NIV for Intubation of AECOPD



Study or Subgroup	High flow nasal cannula oxygen therapy Events	Total	Non-invasive ventilation Events	Total	Weight	Risk Ratio M-H, Fixed, 95% CI
1.1.1 High flow nasal cannula oxygen therapy vs non-invasive ventilation in intubation						
Jing, G. Q.2019	1	22	2	20	13.9%	0.45 [0.04, 4.64]
Myoung Kyu Lee 2018	11	44	12	44	79.8%	0.92 [0.45, 1.85]
Zhang, JC 2018	2	21	1	24	6.2%	2.29 [0.22, 23.44]
Subtotal (95% CI)		**87**		**88**	**100.0%**	**0.94 [0.49, 1.78]**
Total events	14		15			
Heterogeneity: Chi² = 0.94, df = 2 (P = 0.62); I² = 0%						
Test for overall effect: Z = 0.20 (P = 0.84)						
1.1.2 Sensitivity analysis						
Jing, G. Q.2019	1	22	2	20	69.2%	0.45 [0.04, 4.64]
Zhang, JC 2018	2	21	1	24	30.8%	2.29 [0.22, 23.44]
Subtotal (95% CI)		**43**		**44**	**100.0%**	**1.02 [0.22, 4.65]**
Total events	3		3			
Heterogeneity: Chi² = 0.93, df = 1 (P = 0.34); I² = 0%						
Test for overall effect: Z = 0.02 (P = 0.98)						
1.1.3 Paitents with hypercapnia						
Jing, G. Q.2019	1	22	2	20	14.9%	0.45 [0.04, 4.64]
Myoung Kyu Lee 2018	11	44	12	44	85.1%	0.92 [0.45, 1.85]
Subtotal (95% CI)		**66**		**64**	**100.0%**	**0.85 [0.43, 1.66]**
Total events	12		14			
Heterogeneity: Chi² = 0.32, df = 1 (P = 0.57); I² = 0%						
Test for overall effect: Z = 0.48 (P = 0.63)						
1.1.4 Weaning patients from invasive ventilation						
Jing, G. Q.2019	1	22	2	20	69.2%	0.45 [0.04, 4.64]
Zhang, JC 2018	2	21	1	24	30.8%	2.29 [0.22, 23.44]
Subtotal (95% CI)		**43**		**44**	**100.0%**	**1.02 [0.22, 4.65]**
Total events	3		3			
Heterogeneity: Chi² = 0.93, df = 1 (P = 0.34); I² = 0%						
Test for overall effect: Z = 0.02 (P = 0.98)						

Test for subgroup differences: Chi² = 0.09, df = 3 (P = 0.99), I² = 0%

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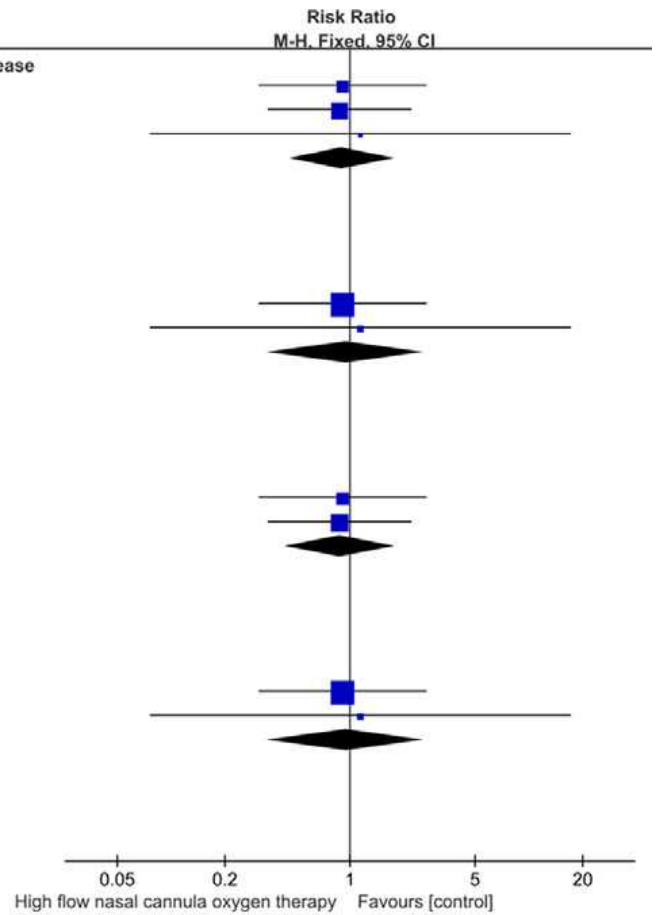
HFNC vs NIV in Mortality of AECOPD

Study or Subgroup	High flow nasal cannula oxygen therapy Events	Total	non-invasive ventilation Events	Total	Weight	Risk Ratio M-H, Fixed, 95% CI
1.2.1 High flow nasal cannula oxygen therapy vs non-invasive ventilation in mortality for patient of acute exacerbations of chronic obstructive pulmonary disease						
Jing, G. Q.2019	5	22	5	20	37.0%	0.91 [0.31, 2.68]
Myoung Kyu Lee 2018	7	44	8	44	56.5%	0.88 [0.35, 2.21]
Zhang, JC 2018	1	21	1	24	6.6%	1.14 [0.08, 17.16]
Subtotal (95% CI)		**87**		**88**	**100.0%**	**0.91 [0.46, 1.79]**
Total events	13		14			
Heterogeneity: Chi² = 0.03, df = 2 (P = 0.98); I² = 0%						
Test for overall effect: Z = 0.29 (P = 0.77)						
1.2.2 Sensitivity analysis						
Jing, G. Q.2019	5	22	5	20	84.9%	0.91 [0.31, 2.68]
Zhang, JC 2018	1	21	1	24	15.1%	1.14 [0.08, 17.16]
Subtotal (95% CI)		**43**		**44**	**100.0%**	**0.94 [0.34, 2.59]**
Total events	6		6			
Heterogeneity: Chi² = 0.02, df = 1 (P = 0.88); I² = 0%						
Test for overall effect: Z = 0.11 (P = 0.91)						
1.2.3 Paitents with hypercapnia						
Jing, G. Q.2019	5	22	5	20	39.6%	0.91 [0.31, 2.68]
Myoung Kyu Lee 2018	7	44	8	44	60.4%	0.88 [0.35, 2.21]
Subtotal (95% CI)		**66**		**64**	**100.0%**	**0.89 [0.44, 1.80]**
Total events	12		13			
Heterogeneity: Chi² = 0.00, df = 1 (P = 0.96); I² = 0%						
Test for overall effect: Z = 0.33 (P = 0.74)						
1.2.4 Weaning patients from invasive ventilation						
Jing, G. Q.2019	5	22	5	20	84.9%	0.91 [0.31, 2.68]
Zhang, JC 2018	1	21	1	24	15.1%	1.14 [0.08, 17.16]
Subtotal (95% CI)		**43**		**44**	**100.0%**	**0.94 [0.34, 2.59]**
Total events	6		6			
Heterogeneity: Chi² = 0.02, df = 1 (P = 0.88); I² = 0%						
Test for overall effect: Z = 0.11 (P = 0.91)						

Test for subgroup differences: Chi² = 0.02, df = 3 (P = 1.00), I² = 0%



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보험 급여 기준(2016.8-)

- 별도의 indication은 현재 없습니다. 단, Flow 기준 충족 필요.

- **행위 수가 : 2015년 7월부터 16,770원 / 1일당 (병원별 가산 금액 별도)**
- **High Flow 기준 : 호흡부전 및 저산소증 환자에게 성인-15L/min, 소아-2L/min 이상**
- **치료재료 수가 : 8월부터 96,000원 상한금액**
- **성인 환자군별 본인일부부담금 5%, 10%, 20% 적용 됨**
- **생후 30일부터 6세까지 영유아 본인일부부담금 10%**

인공호흡기 요양비 지급대상 상병

폐질환과 만성호흡부전이 동반되는 경우	특정기호
호흡기 및 상세불명 결핵의 후유증 (B90.9) + 만성호흡부전 (J96.1)	
일차성 폐동맥고혈압 (I27.0) + 만성호흡부전 (J96.1)	V202
기타 이차성 폐성 고혈압 (I27.2) + 만성호흡부전 (J96.1)	
폐성 심장(만성) NOS (I27.9) + 만성호흡부전 (J96.1)	
기타 만성 폐색성 폐질환 (J44) + 만성호흡부전 (J96.1)	
기관지확장증 (J47) + 만성호흡부전 (J96.1)	
기관기관지의 허탈 (J98.01) + 만성호흡부전 (J96.1)	
기타 명시된 호흡장애 (J98.8) + 만성호흡부전 (J96.1)	
심장질환과 만성 호흡부전이 동반되는 경우	
심장의 선천이상 NOS (Q24.9) + 만성호흡부전 (J96.1)	

신생아, 선천기형(선천성 황격막 탈장, 선천성 T-E fistula)

https://www.nhis.or.kr/nhis/policy/wbhada17000m01.do

■ 요양비의 보험급여 기준 및 방법 [별지 제4호의2서식]

건강보험 인공호흡기 급여대상자 등록 신청서

(앞 면)

①수진자	성명	주민(외국인)등록번호	건강보험증번호
	전화번호 (자택) (휴대폰)	등록결과통보(SMS)	[ ] 예 [ ] 아니오
	진료과목	진단확인일	
	확인사항 상병코드	상병명	
	상병별 검사방법 (※해당사항에 √ 표시)	1. 인공호흡기 요양비 지급대상 상병(별표4의2) 해당 여부 □ 예 □ 아니오 2. 상병별 진단기준에 따른 검사 실시 (해당 번호에 √ 표시) ① 영상검사 □ Sono □ CT □ MRI □심초음파(심도자) □기타( ) ② 특수생화학 / 면역학적 검사, 도말 / 배양검사 ③ 유전학적 검사 ④ 조직학적 검사 ⑤ 임상 진단 □폐기능검사 □수면검사 □그 외( ) ⑥ 기타 특수검사 □근전도검사 □뇌파검사 □그 외( )
②요양기관 확인란	환자상태 및 진료소견 (※해당사항에 √ 표시)	1. 고이산화탄소혈증 2가지 이상의 임상증상 (□ 체외: 의식저하 등으로 의사표현이 불가능하여 임상증상 파악이 어려움) □ 숨이 참 □ 피로감 □ 두통 □ 정신이 맑지 못하고 멍함 □ 밤에 자주 깨거나 낮에 졸리고 토막잠을 자주 잠, 혹은 악몽을 자주 꾸거나 가위에 눌림 □ 불안하여 안절부절 못함 □ 빈맥 2. 이산화탄소 분압 검사(최소 한 가지 이상) □ 동맥혈 가스 검사에서 이산화탄소분압이 45mmHg 이상 □ 호기말 이산화탄소 분압이 40mmHg 이상 ※ 이산화탄소 분압은 2회 이상의 검사결과지 또는 검사결과를 명시한 소견서를 반드시 첨부 3.□ 24시간 지속적인 인공호흡기 사용자로 호흡기를 이탈하여 상기 1,2 검사 불가능(의사소견서로 대체)

위에 기록한 사항이 사실임을 확인함

년 월 일

요양기관명(기호) : ( ) (요양기관 직인)

담당의사성명(면허번호) : ( )

전문과목(전문의 자격번호) : ( ) (서명 또는 인)

위와 같이 건강보험 인공호흡기 급여대상자 등록을 신청합니다.

년 월 일

③신청인 (서명 또는 인)

수진자와의 관계 ( ) 전화번호 ( )

국민건강보험공단 이사장 귀하

본인은 상기와 같이 건강보험 인공호흡기 급여 대상자로 선정·등록된 자로,
1. 개인정보(성명, 주민·외국인등록번호 등), 2. 민감정보(상병 등) 3. 고유식별정보(주민·외국인등록번호 등)를 처리할 것을 동의하며, 이 내용은 정보의 변경 신고(신청)에도 유효합니다.

④본인 (서명 또는 인)

210mm×297mm[일반용지(재활용품) 60g/㎡]

등록 신청서는 반드시 **신경과, 신경외과, 재활의학과, 내과, 결핵과, 흉부외과 전문의**가 발행하여야 합니다. 소아의 경우 **소아청소년과 전문의**가 발행할 수 있습니다.

해당 의료기관의 **전문의**가
<상병별 진단 기준 및 검사 항목>을
확인 후 상병에 맞는 검사항목에 체크합니다.

1. 동맥혈 가스 검사결과지는 **2회 이상 다른 날짜로 45mmHg이상** 입니다.
2. 24시간 지속적인 인공호흡기 사용자로 호흡기를 이탈하여 상기 1,2 검사가 불가능 할 시 의사소견서로 대체 가능합니다.

1. 병원명, 병원코드, 병원 직인 (원무과)
2. 담당의사성명, 면허번호 (해당 전문의)
3. 전문과목명, 전문의 자격번호, 서명or직인 (해당 전문의)

이 부분은 보호자or환자분이 작성해 주셔야 합니다.
1. 신청인 - 보호자or환자 서명or직인 (보호자일경우 관계, 전화번호 적어주십시오.)
2. 환자 본인일 경우. "본인"이라고 적어주시면 됩니다.

1. 환자 성함, 서명 or 직인 (환자가 자필서명을 할 수 없는 경우 보호자분이 작성하셔도 됩니다.)

호스피스·완화의료 및 임종과정에 있는 환자의 연명의료결정에 관한 법률

[시행 2017.8.4.] [법률 제14013호, 2016.2.3., 제정]

"말기환자(末期患者)"란 다음 각 목의 어느 하나에 해당하는 질환에 대하여 적극적인 치료에도 불구하고 근원적인 회복의 가능성이 없고 점차 증상이 악화되어 보건복지부령으로 정하는 절차와 기준에 따라 담당의사와 해당 분야의 전문의 1명으로부터 수개월 이내에 사망할 것으로 예상되는 진단을 받은 환자를 말한다.

가. 암

나. 후천성면역결핍증

다. 만성 폐쇄성 호흡기질환

라. 만성 간경화

마. 그 밖에 보건복지부령으로 정하는 질환

경청해 주셔서 감사합니다.